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A Monthly Popular Journal of Knowledge

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DISCOVERY

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Editorial Notes.

There is certainly one good thing about this election. It is a quick one. I luckily get out of writing a dreary "don't offend either side" string of platitudes for a non-political journal, because the election will be over before you get this. I have one serious grumble against all the parties. Every time I get an Income Tax paper or a Rate Demand Note I meditate and remember that France owes us a lot of money. I believe that supporters of the little inter-allied mutual back-scratching societies think it is very rude of any Englishman to mention this little account to a Frenchman. Yet many Englishmen I know who have spent years in France and know the country well from Merville to beyond Amiens, are all in favour of mentioning it—we could find a useful employment for the sum. In the meantime we have a new Government, an unknown element at the time of writing. What will science get out of this new Government? Do not deceive yourselves. It will be just like any other Government; you will get as little as usual and we shall have to wait for the Budget to know what little we are to be allowed to retain.

* * * * *

With autumn the season of infectious colds and influenza comes upon us. In America they have been developing a chlorine cure which is claimed to abolish any cold in an hour. You sit round and read books in nicely furnished rooms, whose atmosphere is impregnated with the right proportion of chlorine gas and you go away cured. At least, that is what they claim for it, but exact facts on the right proportion of gas to air are lacking, and no clinic of the kind seems to have been established in London yet. The cold is a permanent hardy perennial nuisance and it is high time that it was dealt with on modern lines. The crowding of the great cities has probably raised the average of cases considerably in the last twenty years, and we do not appear to have developed any particular immunity. At the height of a cold epidemic a journey by a tube railway is as good a way of getting infected as any. Schools, theatres, and churches are notorious danger centres, but cinemas are not so bad. The reason for this is probably the sporadic syringing with germicide sprays that is always carried out in the better-class picture theatres. It is effective.

* * * * *

The tubes, too, disinfect to a certain extent with an ozone process. The churches ——. Well, public opinion in this year of grace ought not to be offended if we suggest that religious values would not be impaired if the hygienic precautions adopted in picture theatres were applied in the churches. We do not suggest for a moment the use of sprays during the hours of service, but suggest that they might be of value for purifying the air between services. Anything that combats the mass transmission of infectious colds is useful to the community at large. As things are at present it is very difficult to avoid infection. Healthy children come up from the country and go by omnibus or tube to a shopping centre, visit the Xmas bazaars of the great shops, and go home to develop temperatures and abominable colds. This trouble can be minimised if attention is paid to the problem. Public opinion can do it. A century and a half ago the bulk of the community was unclean and harboured vermin. To-day, we still keep on passing the uncleanly cold from one to another. We want to see improved hygienic conditions. Chlorine gas is

possibly not suitable for sterilizing the air of crowded shops, but other compounds may be and it is not an expensive proceeding. Probably it is good business and the first big shop which deals with the problem and advertises "Come to So and So's Great Sale. Sterilized Air! You cannot catch a germ here!" is going to make a good deal out of it. "Safety First" is probably the best-known slogan on earth and it is high time that we applied it to the common cold, that trivial trouble which is often the handmaiden or forerunner of a number of really serious troubles.

* * * * *

In this number we are privileged to print a special article by Doctor Wall dealing with his assault on the atom. It is one of the most important fighting fronts of science for chemist and physicist alike look to the conquest of the atom as opening a pathway to a vast unknown territory. Doctor Wall has been to no slight extent a victim of misrepresentation in the more sensational daily Press where much space was devoted to misleading suggestions that the experiment would destroy the world. There is no foundation for this idea. On the other hand the experiment is one which may be and very probably is attended with considerable personal danger from an atomic explosion. Nobody knows with certainty what is likely to happen if disassociation takes place, but if rapid disassociation occurs it may mean an explosion. Estimates by eminent scientists of the energy contained in an atom have been rather staggering. On the other hand, the recent breaking down of mercury into gold by Professor Miethe seems to have been accomplished without the evolution of free energy. Anyway, Doctor Wall is going ahead, day after day, with an experiment which may blow him up at any minute. This is admittedly a very plucky thing to do, and it is in the very best traditions of scientific research. We hope and trust that the experiment will be successful and not accompanied by disaster. There will be some who will ask "Is it worth the risk, this splitting of the atom?" The answer is "Yes." It is worth all risks, for its conquest of atomic energy is probably the greatest of all scientific developments, and will in time give man command of undreamt-of forces. The future progress of civilisation of mankind itself may depend on it.

* * * * *

I want to thank the many correspondents who have so kindly sent in lists of the names and addresses of potential subscribers. Copies have been sent to them and the response has been most encouraging. I feel I should congratulate my readers on the splendid quality of their friends. One or two readers have suggested that a wider bookstall circulation is needed, and that more posters should be shown. As things are at present, the paper should be available without special order at all large bookstalls as well as shops. The smaller bookstalls naturally do not carry a wide stock of journals, and it would not pay us—or them—to issue copies of DISCOVERY which might not be bought but would be returned when out of date. In the same way, posters are available in limited quantity, and will be willingly dispatched to anyone who will exhibit one. If you will notify us of any bookstall where you have any difficulty about getting the journal, we will immediately take the matter up. If you live at a distance from a town and find it difficult to obtain regular deliveries of the paper on the first of each month, a subscription form is included in every issue and the paper can be sent to you post free for twelve shillings and sixpence a year. In the meantime we are continuing our policy of sending a free copy of the paper to anyone anywhere if you will send us the names and addresses.

* * * * *

At the suggestion of an overseas reader who occupies an important position at a Dominion university, we are arranging a special free service for overseas readers, schools or laboratories who wish to purchase scientific medical or biological apparatus, books or equipment. We can give them the benefit of the practical knowledge concerning these matters which has been gained by their co-workers in specialised subjects here, and will supervise the execution of orders on their behalf. The overseas reader who requires information or data and who has not access to up-to-date lists, and who may not be in a position to know how recent developments have stood practical usage, should write to us stating his needs.

CELLOPHANE WRAPPERS.

THE new transparent wrapping which looks like the gelatine from Xmas crackers and is used for wrapping chocolates, soap, and even kippered-herrings, is called cellophane. It is made of wood pulp treated with alkalis and carbon bisulphate until it forms a viscose. This solution is forced through slits into chemical tanks containing liquids which solidify the product. It is very similar to the familiar artificial silk used for stockings. It is to be hoped that the habit of packing food materials in this or kindred material will spread. It is clean, hygienic, and fly- and handling-proof.

High-Speed Photography.

By A. H. Hall, C.B.E., M.I.C.E.

(Illustrations and cover block by the author).

An article which states the scientific basis of the new speed photography from a practical point of view. Mr. Hall is the leading authority on the new high-speed cameras and covers in this article all the latest developments.

Our interest as a nation in sport is obvious from a glance at any illustrated daily paper. The editor knows that it pays to devote a considerable space to photographs of current events in football, cricket, tennis, golf, and athletics of all kinds, subjects which all require very short exposure if the figures are to be rendered without movement. The division between what are regarded as ordinary snapshots and high-speed work is quite arbitrary, but if we confine our attention to subjects requiring an exposure of less than about 1/250 sec. we shall include nearly all the sporting events, and exclude, to all intents and purposes, the between-lens shutter.

This limits us to the type of camera fitted with a focal plane shutter.

"MY FISH, I THINK!"
This photograph of pouncing gulls is a remarkable piece of expert work. 1/1000 sec. f.(3.5). Good light.

Types of Camera.

Two varieties of hand camera are usually so equipped—the reflex camera, which from its construction requires a shutter behind the reflecting mirror, and the handy portable type, which often has a fixed bellows extension, the lens being fitted in a focusing jacket, and which is generally known as a Press camera.

The reflex camera enables focusing to be accurately performed, and for those who possess only one camera, is perhaps the better type, as it is more convenient for general work such as portraiture, animal studies, and landscape work.

It is, however, a fallacy to assume that for rapidly-moving objects it is possible to focus up to the moment of exposure; the eyes must be lifted from the hood and directed towards the subject.

It is more bulky, and usually rather more expensive, and except where telephoto lenses of long focus are used, as in cricket, those who earn their living by supplying photographs for the Press almost invariably use the simpler type. In most cases it is possible to determine the distance at which the figures will be taken beforehand, and those who are not expert at judging distances can get an opportunity of a trial focusing beforehand. The camera is always used at eye-level, and a finder is fitted which enables a full-sized image to be seen at the moment of exposure. The patterns of finder vary in the different makes, but in good instruments are generally reliable. I regard it as important that the view seen should be rather less than is included on the plate, as this allows a certain margin, so that, with very quickly moving subjects, a slight error in the time of exposure does not mean that the object is either right off the plate, or a portion only included at the edge.

Shutter Details.

As is well known, most forms of focal plane consist in a blind working just in front of the plate and a slit of variable width passes down at the moment of exposure, the speed of travel being usually regulated by a spring.

Theoretically, as one part of the plate is necessarily exposed before the succeeding portion, the image obtained is not an accurate representation of the object at any particular instant, and occasionally

one meets with examples such as an oval motor-car wheel with curved spokes. In actual practice, if the speed of travel of the blind is sufficient, it is rare to meet with any distortion which matters.

The efficiency of a good focal-plane shutter is high, i.e., a large percentage of the available light reaches the plate, but for this condition to be obtained it is essential that the blind should be as near to the plane of the sensitive surface of the plate as possible.

What is not so well known is that when the slit width is very narrow for minimum exposures, the efficiency may fall off very rapidly with the lenses of extreme aperture which are now becoming so popular.

The formula for the efficiency of a focal-plane shutter as worked out by M. Wurtz is

$$R\frac{F}{F + d\frac{p}{D}}$$

where

F is the width of the slit ;

d is the distance of the slit from the focal plane ;

p the aperture diameter of the lens ;

D the focal length of the lens ;

from which it will be seen that the wider the slit the higher the efficiency and also that the efficiency decreases when d is increased, and also when $\frac{p}{D}$ or the f.no. of the lens increases.

"A PARABOLIC CURVE."
The speed of the lens can be judged from the beautiful curve of the water flung from the child's bucket. Exposure 1/500 sec., f.(2.9), 4¼-in. lens. Dull day.

The efficiency further is independent of the speed of travel of the blind, and it follows that, if the construction of the shutter will permit it, the shortest exposures should be given by having the slit width as wide as possible and the spring tension at its maximum. There is a limit to the speed of travel, and consequently for high speeds the slit width must be narrow, while it is mechanically impossible to bring the shutter nearer to the plate than a certain minimum distance.

Actually, with a lens working at f.(4.5) and the width of slit equal to its distance from the plate, the efficiency never falls below 83 per cent, but with the extreme aperture lenses now being used the efficiency may be much less, as in many shutters the slit width in addition may be considerably less than the distance from the sensitive surface.

These principles have been enunciated at some length, as recent advances in optical construction do not appear to have been attended in all cases by improvements in the shutter, and the combination of a very large aperture lens with an inefficient shutter is much more expensive, and may be little better than a lens of more moderate aperture with a good shutter.

There is one annoying trouble which may be experienced at times when working at the highest speeds, and that is bands of uneven density in the negative. The actual cause is obscure, but is generally attributed to the slit being slightly out of parallel during the exposure, and possibly also to creep, that is to say, the slit width may vary during its passage in front of the plate, a defect which should be capable of remedy.

Optical Considerations.

As regards the standard optical equipment there is some divergence of opinion.

Personally, I am strongly in favour of working in small sizes (with subsequent enlargement), using a lens of large aperture. I find no difficulty after a little practice with a lens covering a 3½-in. by 2½-in. plate at f.(2.9), though a 3-in. lens of the same relative aperture on a 4½ by 6-cm. plate is even easier to use.

Lenses even faster than this are now available as a result of the competition amongst optical firms, and they may have their uses in really expert hands, but the depth of focus is so small that their use at full aperture is decidedly limited.

If a plate as large as quarter-plate is used, a reflex camera is necessary for the amateur with these rapid lenses, and even then the occasions where they can be used without stopping down will be few.

In this size or larger I should recommend an f.(4.5) lens, though some extremely capable workers prefer a lens of less aperture still, namely f.6.

A considerable amount of Press work, notably the wonderful cricket photographs which are common in the daily Press, are done with fixed-focus telephoto lenses working at f.(5.6). As these will be used at considerable distances there is a fair amount of depth

available, and they are not so difficult in operation as might be imagined. They are not recommended until some experience has been gained, but there are many interesting subjects where they will be indispensable.

Prevision.

It is an interesting speculation as to what proportion of Press photographers realise what a wonderful thing it is that they get their figures or other moving objects in approximately the position they intend, for they do not generally release the shutter until they see in the finder the action they wish to portray.

Now the latent period, or time which elapses between a visual impression and the muscular action which results, in this case, in the release of the shutter, is not a constant but is rarely less than 1-10th sec.

The experienced photographer does not, however, find on developing an exposure of a sprinter breaking the tape that the runner is a yard past the winning post, but that he is in the position he saw in his finder.

Dr. Adolphe Abrahams, who combines a medical training with unique experience and success in high-speed photography, openly says that through past experiences one sees an event in advance of its actual occurrence, and that this anticipation neutralises the lag caused by the latent period, and instances the psychological anticipation of vision which is known in astronomical observations.

"NOW JUMP!"
1/1000 sec. exposure on a dull day with a 3-in. large-aperture lens.

Practically, wherever possible, I always get my models to rehearse the position I require, but whether this increases the anticipatory factor or decreases the latent period I am unable to say.

It has been considered impossible to test the theory owing to the difficulty of devising a series of motions which could not be foretold by the photographer, who would know, and anticipate, the action which he desired to record. It appears, however, that an interesting experiment could be devised with the aid of the cinematograph. The finish of a hundred-yards race, for example, could be projected with a very powerful light and the photographer told to make a number of consecutive exposures of the winner on the tape.

The first time, the film would be projected normally; the second time, a portion representing a period less the usual latent period would be cut out of the film, and replaced by numbered blanks. If prevision existed, the photographer would see the anticipated finish of the race before the film of the runners ceased, and actually would record a numbered blank on his plate.

The next projection should be the normal film again, partly to keep the photographer in doubt as to the sequence of events, and partly to test whether his previous experience had altered his latent period.

After this the film would again be run through, but the amount cut out would be slightly increased, the complete and mutilated film being projected in an irregular sequence, so that it would be impossible to anticipate what was actually happening.

There might be practical difficulties in carrying this out but, if possible, it should give some exceedingly interesting data.

Exposures.

The tables published in most handbooks giving the exposures necessary for various speeds of moving objects are useful as a rough guide, but they are only concerned with the general speed of the object and make no allowance for local movements such as those of the arms and legs in jumping, and it is these which determine the exposure if sharp results are required. Experience only can decide what is the longest exposure permissible for most of these subjects, whilst the amount of blurring which can be allowed depends, of course, on whether a contact print or an enlargement is required. It has often been stated that by taking the image smaller a slower exposure can be used, and the image subsequently enlarged. If the negative is enlarged of course the movement becomes the same as if the image were photographed direct to this size in the first instance. The advantages of a smaller image are that near objects require a relatively longer exposure to render shadow detail, and in bad light there is some gain in not taking the photograph too close.

There are, of course, limits to this, as the worse the light the more the intervening atmosphere obscures the image, while in such circumstances the plate will probably have to be forced in development, which will give a grainy image and preclude satisfactory enlargement.

Plates and Speeds.

There is much controversy as to the best plate to use in adverse conditions. The H. and D. number quoted on the box is not a true measure of the speed, which cannot be represented by a simple expression.

No one can do better than adopt a well-known brand, and use the particular variety which the makers will recommend for the work in hand. Plates with very high H. and D. numbers specially made for portrait work usually have a low contrast factor, and should be avoided by the beginner. There is, however, so little to choose between plates marked 600-700 H. and D. and those marked about 450 H. and D. specially made for Press work—i.e., plates which will stand forcing in development—that the use of one or the other is entirely a matter of personal preference.

Development.

Where the light is good and the plates have received sufficient light impression, development can follow the normal course, though the tendency to over-develop must be watched.

Unfortunately, where the plate is partially under-exposed the correct method of dealing with the under-exposed portions is not suitable for the high lights on which the exposure has been adequate; that is to say, forcing the plate will block up these parts before all possible shadow detail has been obtained.

Generally a compromise is best, and the high lights should be rather too dense, so that there is some chance of a silver deposit in the shadows by the time that development is stopped.

Various expedients which are not yet past the laboratory stage have been proposed, and perhaps the most promising is to develop until the image appears, and then to lower the plate face downwards on to some surface which will exclude air, and prevent aerial oxidation. Though a certain amount of diffusion from one part to another of the film will take place, the developer will become exhausted on the parts which have been fully exposed before action on the other portions ceases, and by this means the high lights may be prevented from acquiring excessive density.

If the plate is totally under-exposed the best course is to use the most energetic developer possible at as high a temperature as will not cause palpable fog.

In any case, the exact degree of development wants very careful watching, and it is a great advantage to desensitise the plate with pinakryptol green and develop by a bright light.

Printing.

It is not often realised that almost as much skill is required in the printing as in the developing. Some of the plates which are totally under-exposed will be very thin, and some will, as explained above, be too dense in parts.

"A ROUGH-HAIRED LENGLEN."
1/1000 sec., f.(2.9). No sun.

I am very strongly against intensification of the thin negatives, which invariably increases the grain, as this is the bugbear of enlarging these small negatives, and the reduction of the over-dense parts of the other type of negative is also risky.

It is necessary, therefore, to use printing papers with different degrees of contrast, a soft paper for the dense negatives, and a hard paper for the thin ones.

Tidal Power.

By Norman Davey, M.A., A.M.I.C.E.

Mr. Norman Davey is not only one of our most promising writers of modern fiction—"The Pilgrim of a Smile" and "Guinea Girl" were enormously successful—but he is also the leading expert on tidal power. Very few people know anything about this subject, yet it is one of the greatest problems engineers have yet to solve. Here is a brilliantly informative article giving the whole situation to-day.

TWICE a day, along all coasts on the face of Earth, a great mass of sea water is raised to a varying elevation by the attraction of the moon. Whenever any weight is moved away from the gravitational centre of the earth, work is done upon the weight; and, conversely, if the weight is allowed to fall the same distance that it has been raised, a quantity of work is done by the weight in falling as was expended on the weight in raising it. Thus, if a mass of water be confined or impounded at the highest elevation to which the moon has raised it—that is to say, at what is called high-tide: if that mass of water be kept there until the sea-level has fallen to its lowest level—that is to say, to low-tide level; and if the mass of impounded water be now allowed to fall to this lower level, then work will be performed by this mass of water in falling as was done by the moon on the water in raising it. Thus the power of the tides is in reality the power of the moon; and if all the water in all the seas in the world could be so ordered and confined, the moon herself might well take umbrage at being so made use of; earth might be affected in her rotation and the very calendar be upset. But there is small fear of such untoward effects in what little lunar or tidal power may be practically and economically utilized.

Lunar Pull.

There are factors that confine the tidal power actually available for man's use, to a tiny fraction of the power extant. The first is the necessity of having a natural basin or indentation in the coast-line in which the tidal flow may be efficiently enclosed; the second, the need of a sufficient tidal rise to operate effectually the machinery employed.

If we consider the second condition first, we will find that the variation in tidal range over the earth's surface is very great. A maximum value is found in the Bay of Fundy in Nova Scotia, of 50 feet; a minimum in the Adriatic (at Zara) of half a foot. This represents a variation in height of 100. Now, the energy derivable from a falling body varies as the square of the distance through which the body falls. A given mass of sea water, therefore, will give out 10,000 times as much power in Fundy as it will at Zara. In these islands, where tidal power is alone of practical interest to us, the variation is still great. A maximum tidal range is observed at Avonmouth of 41.8 feet and a minimum in Ballycastle Bay of one foot, giving a variation in power of 1750. There will clearly be a limit in range below which it is impossible economically to make use of the tides in respect to the mechanical means for so doing at present available. What this exact limit is, is a matter of varying expert opinion, but it may broadly be considered as impolitic, if not impracticable, to attempt to utilize the tides, where the mean tidal range is less than ten feet.

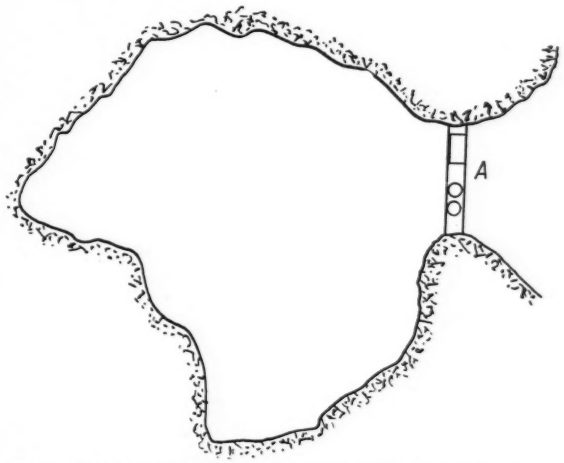


FIG. 1.—DIAGRAM OF NATURAL BASIN DAMMED AT THE MOUTH.

In respect to the first condition postulated above, it is clear that to attempt to impound a mass of sea water of any size, without aid given by the natural configuration of the land, would again be impracticable. To build walls out into open sea to form the enclosing basin would be folly, both in respect to cost involved and durability of structure.

We are, therefore, confined in the use of tidal power to such localities as have a sufficient tidal range and a natural basin within which to confine the water—such a basin, for instance, as is shown in plan, in Fig. 1. In such a natural basin, a dam is built across its mouth at A; gates are provided for the inflow or outflow

of the water and turbines are set in the dam, through which the water may flow and the resultant power transmitted as soon as the required condition of head of water is reached. The number of basin systems for utilizing tidal power are many; and some are very ingenious and complex. It is beyond the scope of this article to go into so special and technical a matter. But in point of fact, what is called the "half-tide" system is simple enough; and this system (or a variation on it) is the only one likely, in normal cases, to be used.

In this system, the retaining dam is equipped with outflow turbines and inflow gates only. The operation diagram, which is simply a time-range graph, is shown in Fig. 2.

XYZ represents the level of the water in the sea over one tidal cycle—that is to say, from high-water at X, to low water at Y and back again to high-water at Z, over the twelve-hour period. The thick line, XABCZ, represents the level of the water in the basin.

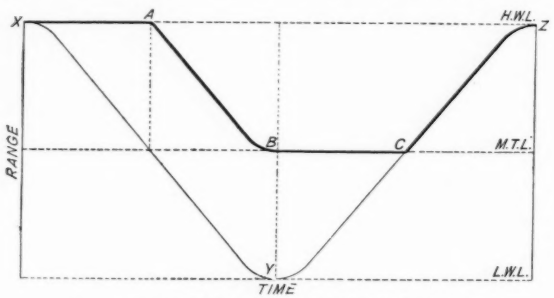


FIG. 2.—TIME RANGE GRAPH OF A TIDAL CYCLE.

At X the levels of the water in sea and basin are coincident at high-tide. Both turbine gates and inflow gates are now closed. The tide level outside falls to half-tide level. At this point, A, there is a difference of head between sea and basin equal to half the tidal range and at this point the *turbine* gates are opened. The flow through the turbine is so controlled as to maintain a constant head; the water in the basin falling along AB parallel to the sea outside along XY. At B, when the sea-level has now reached low-tide level, all gates are closed. The sea-level now begins to rise along YC, while the level in the basin is constant along BC. At C, the *inflow* gates are opened and the levels of the water in sea and basin rise coincidentally along CZ, until high-water level is reached at Z and the cycle is repeated.

It will thus be seen that the turbines are at work for three hours, out of every twelve hours, at a head equal to half the range of the tide.

And this brings us to the essential and peculiar difficulty in the exploitation of tidal power—that is to say, its variability.

For tidal power is always variable, and, except in certain specialized basin systems, intermittent.

Let us consider this variability.

Owing to the altering phases of the moon, the tidal range in any one place varies throughout the lunar period. This variation is usually over three and may, on occasion, exceed four. Since, as we have seen, the power varies as the square of the head, the consequent power variation is of from 10 to 16 or more. This means that, in any markets where continuous power is needed—which, with the exception of automatic chemical processes and one or two special exceptions, means all power markets—a method of storage is necessitated. This storage of power has to be made over half the lunar period and works out to a storage capacity (under the half-tide system) of from 60 to 70 hours. The time of storage for intermittency under the half-tide system (as has been already seen) is nine hours. Since 60 hours' storage *have* to be provided in respect to lunar variability, the nine hours' storage due to intermittent working is contained therein and need not be considered.

High-Level Storage.

This storage of power can only, in practice, be made by the conserving of water at a requisite height. All other forms of storage (i.e., electric accumulators or compressed air) are applicable only to extremely small powers. Therefore, any tidal power system necessarily consists of:

(*a*) Primary turbines worked by the tidal head.
(*b*) A high-level reservoir.
(*c*) A low-level reservoir.
(*d*) The necessary pumping plant to raise water from (*c*) to (*b*).
(*e*) Secondary turbines working between (*b*) and (*c*).

In a few (unhappily, a *very* few) localities, sites may be found for the storage reservoir near enough to the dam to admit of direct pumping; in which case the tidal basin becomes the low-level reservoir. In most cases, however, suitable contours for reservoir construction are only to be found at a distance from the tidal basin; so that two reservoirs are needed together with the necessary electric transformation and transmission between the dam site and the reservoir site.

A diagrammatic representation of such a complete system is shown in Fig. 3. The sea turbine drives an alternator; the current is conducted to the motor driving the pump, which pumps the water from the lower to the upper reservoir; from which in turn works the secondary turbine driving the secondary alternator which delivers current to the consumer.

This, in barest outline, is the system to be used and the apparatus needed to translate the power of the tides into electric energy for common use. Economically, it resolves itself into three main categories :

(*a*) The costs of dam and sea-water generally.

(*b*) The costs of machinery and necessary transmission.

(*c*) The costs of the reservoirs.

Having seen what works and plant, the exploitation of tidal power entails, let us consider how much power is available in Great Britain.

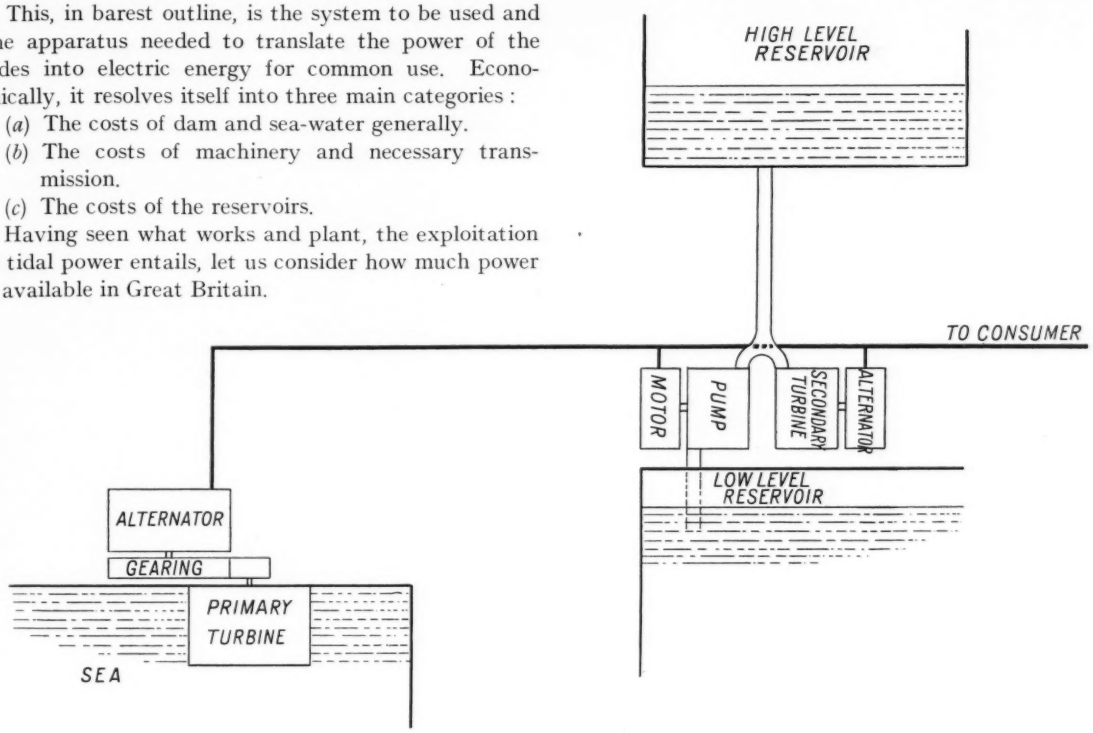


FIG 3.—DIAGRAM OF A COMPLETE TIDAL POWER INSTALLATION.

If we exclude the use of any coast-line where the mean tidal range falls below 10 feet and include only such bays, estuaries and indentations in the land, as would make a dam construction reasonably possible, a tidal survey of these islands gives a grand total of *possibly* available output at four million horse-power continuous. If, however, we assume a more conservative estimate, eliminating a number of the less favourable localities, a fair maximum of three million may be taken. Assuming conversion losses between the tide and the consumer of 50 per cent, the total electrical energy available is 1,500,000 horse-power continuous, or an annual output of about 10,000 million Board of Trade units.

An idea of the size of this total may be gained when it is considered that the total output of power from all coal-fired electricity stations in this country was, in 1921, 4,955 million units, or less than half of the above total quoted.

The tidal power problem is, however, entirely an economic one. The power is there in abundance. There is nothing new or unknown or untried in the details of its translation. The construction of sea walls ; the use of low-head turbines ; the centrifugal pumping plant ; reservoir making ; pipe-lines ; high-tension transmission and so forth are all well known to engineers. The thing can be done. But can it be done economically ? Can it produce power cheap enough to compete with other and existing sources ?

This is naturally a matter very difficult for the theorist, however laborious his research, however complete his statistics, to opinion upon. But, as far as was possible for a student, without the aid of special geological surveys and borings made in particular sites, to estimate such costs, I have gone carefully into the estimated costs of three typical schemes of a comparatively small output. These were for sites at Salcombe (in Devonshire) ; Fleetwood (in Lancashire) ; and Barrow-in-Furness. These outputs and costs may be tabulated as follows :—

	Output in B. of T.U. per annum.	Cost per KW (continuous)
Salcombe	14,000,000	£125
Fleetwood	52,000,000	£168
Barrow	160,000,000	£150

Salcombe gives an unusually low cost figure, as here the pumping to storage was direct.

The Severn scheme, as proposed by the Ministry of Transport in 1920, was estimated (then) at £28,000,000 for 200,000 horse-power continuous output or £188 per KW. continuous. Suppose we take £170 per KW. continuous as a fair average figure.

Average Cost.

Let us compare this with the costs of coal-fired power stations.

Now the average cost of medium-sized, steam-power stations (load factor 33 per cent.) is £130 per KW. installed, based on the Water Power Resources Committee's Report, and the annual coal charge is £10 5s. If this charge be capitalised at 10 per cent. the total capital equivalent is £235. This compares favourably with £170 for tidal power as quoted above. For very large powers (100,000 KW.), with 80 per cent. load factor, the corresponding figure is estimated at £60.

Now, with tidal power systems, where storage is necessitated, the lowering of the load factor does not affect the cost of installation. Thus, when the ordinary industrial load factors of 35 per cent. to 25 per cent. are in use, the advantage clearly lies with tidal power; when this factor rises to 70 per cent. and over, in large and economical coal-fired stations, the balance lies the other way.

But there is one very important plea to be made for tidal power in respect to non-storage systems, working intermittently. Many electro-chemical processes admit of this: e.g., nitrogen fixation. Here the primary turbines can drive D.C. dynamos direct and the costs of reservoirs and all the necessary machinery are eliminated. In such a case, the installation costs per KW. continuous, for the three schemes already noted above, become:

	Cost per KW. continuous.
Salcombe	£54
Fleetwood	£44
Barrow	£41

These costs are well below even that of the large coal-fired stations with an 80 per cent. load factor.

In conclusion, the situation in respect to the exploitation of tidal power may be summed up as follows:—

There are no theoretical or fundamental objections to the working of a tidal power station. There is, at least, a *prima facie* case for its successful economic working in ordinary industrial markets; and an almost proven case for its economic working, wherever intermittent working is allowable.

Objections to such economic working lie in:

(*a*) The unit cost figures here adopted being too low.

(*b*) Obstacles set up by vested interest affected.

In the former case, remedy lies in the hands of the engineers. The cost of the machinery in all storage schemes is the biggest item. In the Severn scheme it was estimated at 58 per cent. of the total expenditure; in the Fleetwood scheme, 56 per cent.; in the Barrow scheme, 64 per cent. It is for engineers to cheapen the costs of such machinery specially designed and adapted for tidal power conditions.

In the latter case, remedy must lie with the Government.

In any new proposal—especially in this country—innumerable vested interests always claim, rightly or wrongly, to be adversely affected by the undertaking, and demand to be bought out at fantastic figures. Unless brigandage of this kind is summarily dealt with, little progress will be made in the exploitation of this, one of our first national assets.

RUBBER CELLULOID PRODUCT.

RUBBER has now been combined with celluloid and a flexible varnish obtained. The rubber is dissolved in benzine and the celluloid in amyl acetate. These solutions are emulsified with hexalin and on drying the constituents do not separate.

The new varnish adheres well to metal and glass. Five per cent. of celluloid added to rubber makes a plastic compound, but ten per cent. produces a hard flexible varnish which may have great commercial applications.

SYNTHETIC DIAMONDS.

FROM a Swiss source there comes an account of an experiment by which a mixture of carbon disulphide and a metal with affinity for sulphur were compressed together at a pressure of 8,000 atmospheres for fifteen minutes.

When the remaining metal was dissolved in acid a small residue of transparent irregular crystals capable of scratching glass were found. These fell to powder in a few days.

There have been many attempts to form synthetic diamonds and recently doubt has been voiced that Moissan, the eminent French chemist, succeeded in producing real diamonds. He may have been deceived by carborundum crystals.

It is possible that investigators of the future making use of colloidal metals may succeed where others failed. It is not clear whether colloid metal was used in this Swiss experiment, but the suggestion may be of use to those interested in this form of research.

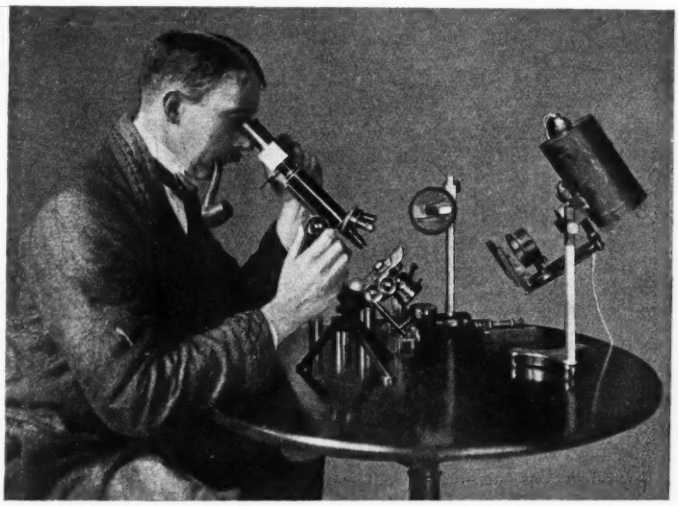
What the Bullet Tells.

By Hugh Pollard.

A man may be hanged or acquitted on the facts ascertained by an expert's scientific examination of the fatal bullet in a murder case. Recent research work has done much to determine the individual characteristics of weapons shown by the cartridge case and fired projectile. Such work has considerable medico-legal value.

Copyright in U.S.A. by Hugh Pollard.

THE problem of deciding whether a given bullet has been fired from the pistol found on an accused individual is one of the most delicate problems that can be presented to an expert on small-arms. In most shooting cases technical evidence such as can be given by a skilled gunsmith is sufficient when used in conjunction with the medical evidence, but from time to time there occur cases which are beyond the province of the medical man and far beyond the gunsmith. Then the services of a scientific expert on small-arms are required. The most important case of this nature is that of the Abbe Delorme of Montreal, Canada, who is accused of murder. Two trials have already been held and in each case the jury disagreed. A third is due this month and, as the case is thus *sub judice*, cannot be further discussed until settled.



MEASURING THE WIDTH OF THE RIFLING GROOVES WITH A MICROSCOPE MICROMETER.

Exact medico-legal knowledge of small-arms is curiously scarce and the standard textbooks on forensic medicine used by students on this important branch of the subject are disgracefully out-of-date. Little special work of this nature has been done in Britain, and nothing published. For test cases and books we must turn to America and France, where the subject has been more closely studied, and where considerable importance is attached to it.

Need for Knowledge.

The ignorance of the average medical man is excusable, but it was brought home to me in 1915 when in France I sat as a member of a field court-martial dealing solely with cases of self-inflicted wounds, under the general charge of "conduct prejudicial to good discipline."

I have never been able to dispel an uneasy impression that at other courts-martial dealing with this type of crime many men must have been unjustly convicted because neither the medical witnesses nor the members of the courts knew enough about the effects of small-arms at close range to decide whether the wounds were self-inflicted, intentionally or accidentally, or whether they were due to enemy fire.

Military conditions such as prevail in wartime do not admit of the precision customary in a civil case, but it is clear that there is a need for wider knowledge of the whole subject. In civil cases all the resources of science are at the command of the prosecution and, in a lesser degree, though usually limited by financial considerations, the defence is as well-equipped.

Murder Cases.

In the case of a charge of murder where it is important to exhaust all means of deciding whether a bullet found in the corpse was fired from the actual pistol possessed by the accused, a very complex process of research has to be carried out.

Pistols and revolvers are made to fire cartridges, the bullets of which correspond to certain calibres or arbitrary designations. Thus, the common pistol of .380 calibre, familiarly called the "thirty-eight" is actually of .35″ calibre. Further, there are at least six automatic pistol cartridges of nominal .38 or 9 mm.

calibre whose case-lengths, charges and weights of bullet are totally different. It follows that the mere correspondence of the diameter of the bullet with the seized pistol is insufficient to connect them. The expert, having measured the bullet to arrive at the calibre, then weighs it in order to ascertain which of the series of cartridges it corresponds with. If the pistol is only capable of use with a cartridge of different dimensions a strong possibility of error is immediately introduced, but in exceptional cases cartridges meant for one kind of pistol may conceivably be discharged in another. Still, even if calibre and weight are right, further research is necessary.

Rifling Marks.

The interior of pistol and revolver barrels is rifled, that is to say, it is not smooth but fluted with grooves which have a longitudinal twist. These grooves grip the bullet in its progress up the barrel and impart to it that spin which preserves its accuracy of flight.

These seven cartridges all have different bullets yet all fit the ordinary Service revolver. There are over forty different makes and types of cartridge which fit the ordinary Army Service revolver of .450/.455 calibre.

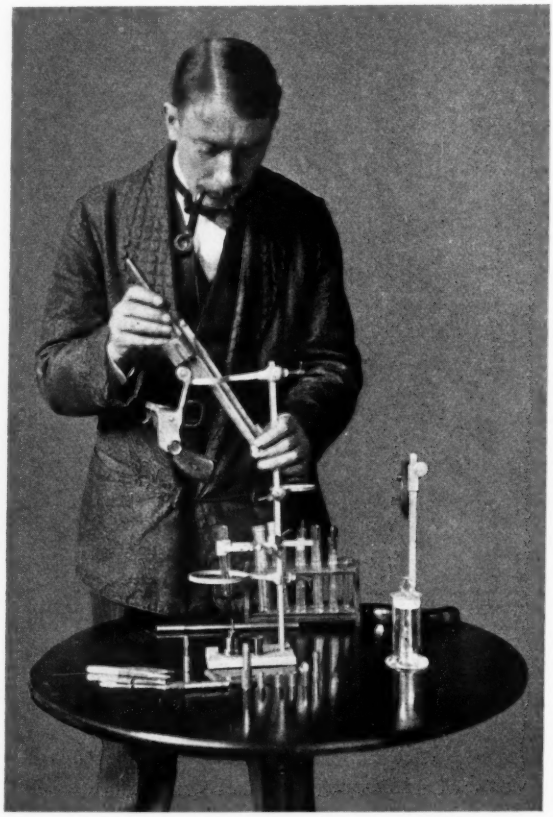
The rifling thus permanently marks the bullet, the grooves of the pistol barrel appearing as raised "lands" on the projectile and the raised portions of the barrel appearing as depressions or grooves on the bullet.

Every make of pistol has its own special type of rifling consisting of so many grooves of a certain width, depth and pitch. In addition the grooving is either right- or left-handed. That is to say, it spins the bullet clockwise or counter-clockwise, a property spoken of as "twist." The expert first reviews this question of twist, for a .25 auto-bullet fired from a Colt .25 auto-pistol is indistinguishable to the naked eye from a similar .25 bullet fired from a Browning .25 pistol, except that the twist is reverse in the two pistols. Next he makes certain that the rifling marks on the bullet correspond with the pistol rifling.

First Steps.

Let us suppose that so far the bullet and the pistol agree, even so we have only got to the point where in evidence we can say that the bullet corresponds with ammunition normally used in and fitting the weapon in the case. Any other pistol of similar make might have been used. Pistols of other make might even produce apparently similar marks on the projectile.

At this point the expert supersedes the gunsmith, and the question narrows down to "Is it possible to decide if that particular pistol found on the accused *and no other* fired that particular bullet?"



MAKING A WAX OR SULPHUR CAST OF THE RIFLING OF A REVOLVER BARREL.

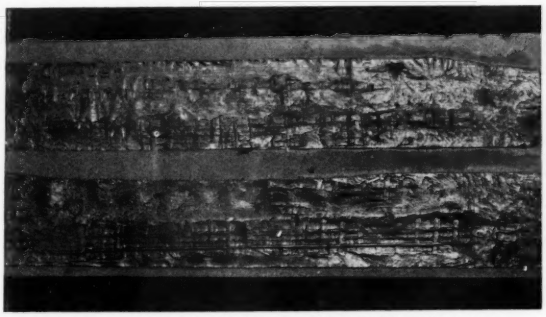
This question can in some cases be definitely answered, in others the margin of ascertainable fact is so small that no unqualified answer can be given.

Permanent Characteristics.

Every pistol has certain individual differences from any other pistol of the same kind. These are known as "permanent characteristics." If such a peculiarity can be found which makes a special individual mark on the projectile, the correspondence of pistol and bullet is proved.

To this end then the expert compares the bullet from the body with a bullet discharged from the suspect pistol. In order to avoid deformation, this latter is fired into a roll of wadded cotton quilting which stops its progress without flattening it in any way. In addition he makes a wax or sulphur cast of the inside of the barrel which aids him in deciding whether the twist of the bullet and barrel coincide.

The two bullets are then rolled along a strip of tinfoil placed on a flat bed of plasticine. This strip records the rifling impressions and any great similarities or discrepancies between individual lands and grooves are quickly noted. Should this test fail to show wide differences the bullets are compared under compound microscopes, firstly through a binocular whose stereoscopic effect is useful, and then micrometric measurements of each groove and land are made and plotted out in rotation. This operation is by no means easy,



TWO SETS OF RIFLING MARKS MADE BY ROLLING FIRED BULLETS ON A PREPARED SURFACE.

The top one shows the marks of the Colt revolver, the lower the distinctive marks of the Webley. Note how the twist of the rifling is reversed in the two examples.

as the observation of cylindrical surfaces under even low powers requires special methods of illumination and extremely precise technique.

If in process of manufacture the rifling tool has worn or has been resharpened on one particular cutter, this groove will be narrower than the others so that the corresponding land on the projectile is also narrower. If this abnormality occurs on both the suspected and the "control" bullets the field of research is narrowed. If delicate measurement reveals a sum of irregularities peculiar to the pistol on both bullets the case is almost proved. The loophole occurs in that the preceding and succeeding barrels rifled by the machine will have had similar characteristics. The chances of an identical barrel being used are remote, but cannot be excluded, and it is a point certain to be brought forward by the defence.

The expert therefore seeks for further marks on the bullet apart from the rifling characteristics. These are very hard to be certain about, and there is no doubt that in certain cases in the past inaccurate evidence has been given and serious miscarriages of justice ensued.

On every bullet, independent of the rifling marks, are certain patches, scratches or surface erosions. These are commonly and wrongly attributed to rust in the barrel. Actually they are factors almost certainly due to metallic fouling from the fore-part of the projectile rolling up between the barrel surface and the bullet. They are not permanent characteristics in that they are variable and may alter in incidence or position with every shot, or remain fixed for a few

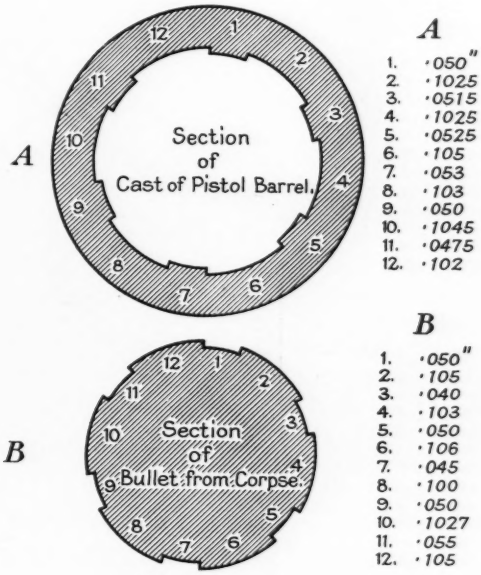


DIAGRAM OF BULLET AND BARREL

showing how measurements of the rifling marks determine that this bullet cannot have been fired from this barrel although it is the proper size and calibre.

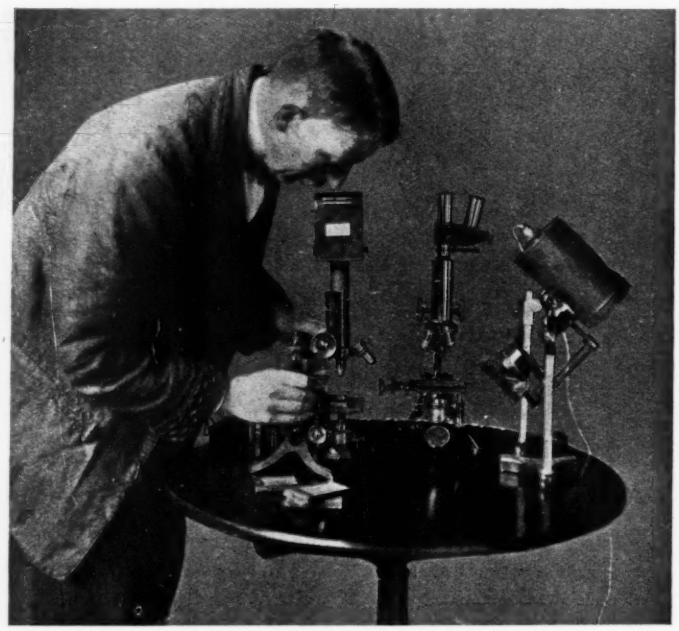
shots and then change. No reliance can be placed on these *striae*, French and American experts notwithstanding.

Reliable Marks.

The marks on which reliance can be placed are those caused by any scratch or deformation *at the muzzle of the bore of the barrel.* These will always repeat and will leave their signature on every projectile fired. A classic case of this type was a murder committed with a cheap type of revolver in which the foresight was a mere pin screwed into the barrel. In this particular pistol it projected slightly inside the barrel so that every passing bullet was scored by it in a characteristic manner.

The sum of rifling correspondences plus any definite characteristics can be taken as confirming the case that can be drawn from bullet and pistol alone. If, however, we have a little more to go on a far more imposing structure of useful fact can be built up. Let us suppose that in addition to the suspected pistol, ammunition was found on the accused. Can we prove identity between the ball from the body and the unused ammunition ?

Here the expert in arms can only be guided by the external characteristics of the bullet which will vary according to the brand of cartridge used. He can, however, call chemist and physicist to his aid and their evidence will prove or disprove that the nature of the lead alloy in the bullets is identical with that in the bullet from the corpse, and that the nature of the outer cupro-nickel coating is also the same. This can be done either by analysis, or by spectrographic tests, the latter preferable as affording evidence which can be shown in court.



TAKING A MICRO-PHOTOGRAPH OF MARKINGS ON A BULLET FORREPRODUCTION IN COURT.

The Cartridge.

If, in addition to the bullet recovered from the corpse, we have an empty cartridge picked up on the scene of the crime, we have every chance of solving our problem with ease. An automatic pistol, unlike a revolver, ejects its own empty cartridge case and a murderer is not likely to stay to pick it up. This is a very important point whose true value should be more widely recognised. The empty case may be the most important clue of all.

It bears on itself numerous marks inflicted by the moving parts of the pistol, and these marks vary with the individual arm and are not likely to be reproduced by any other arm if one excludes mathematical probabilities running to one chance in many millions.

First, there is the mark of the firing pin or striker whose head makes the depression on the cap of the cartridge. The shape and eccentricity of this vary. Secondly, there is the mark on the base of the cartridge caused by the gas pressure blowing it back against the bolt-head. Under the microscope the metal of the cartridge will reveal the imprint of file or tool marks on the bolt-head and any minute irregularity will be registered on any cartridge fired in the arn. Thirdly, there is the extractor mark made by the extractor hook ; and fourthly, the mark made on the base of the cartridge by the ejector. All these are individual to a particular pistol.

The Chain of Evidence.

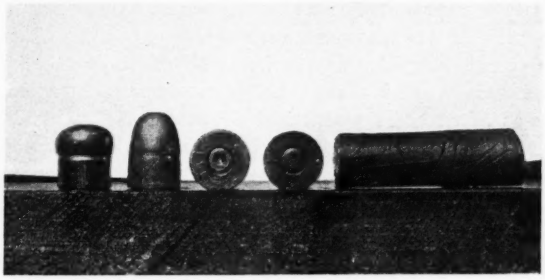
In a recoil or gas-operated mechanism such as the automatic pistol, the operation of ejecting the fired case is performed with violence and all these marks show. Comparison of cases of cartridges fired from the pistol will show uniformity, possibly not in all four sources of deformation but certainly in one or more. Very marked disparities will exist between pistols of similar make and consecutive makers' numbers, for the parts are not assembled in strict rotation as they drop from the machines, and the rifling similarities—that is to say, the possibility of a succeeding pistol having the same small error—does not hold good.

In this way the arms expert working on the material available is able to build up his chain of facts showing how the bullet, the empty cartridge case, the pistol and the unused ammunition must all be considered in their relationship to the crime. In most cases this technical evidence will be reinforced by other circumstantial evidence, but, however strong the latter may be, if the expert can definitely prove that the bullet in the body could not have been fired from the pistol of the accused, the case collapses or the prosecution must change ground and produce another pistol.

objection raised with regard to

Sometimes the question is put "Can you tell from just a bullet what pistol it has been fired from?" In some cases one can say fairly definitely "Yes, it is a .455 Service revolver bullet, probably fired from a Webley revolver." In another case the answer is "No; I have a list of about seventy-five different pistols which use that kind and calibre of bullet, many of them are closely similar, few have peculiarly distinctive rifling. I may be able to locate it as belonging to one of these, but, on the other hand, it may be one of a group of twenty or more."

At present no centralized bureau exists where the police of the world can find standardised particulars of all pistols and firearms. My own private collection contains a fairly exhaustive series of one or two particular calibres, and a more comprehensive one is maintained by one of the American police departments who have a regrettably greater need for it owing

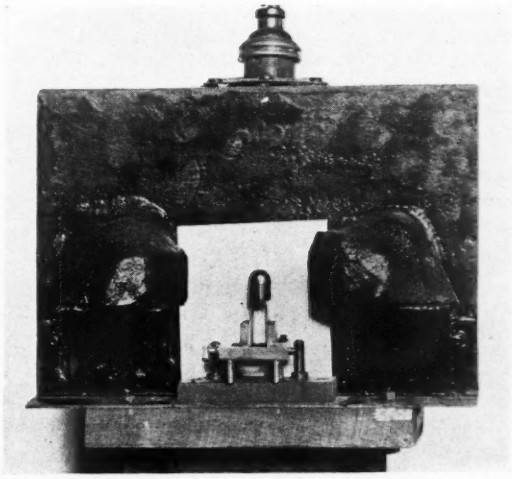


From left to right: (1) A fired bullet. (2) A test bullet from similar weapon fired into cotton. (3) A fired cartridge showing extractor marks. (4) A similar unfired cartridge. (5) A wax cast of the pistol rifling.

to the prevalence of shooting cases in the United States.

Recent research work on the identification of powders from microscopic deposits of unburnt grains and residue found round the wound of entry or enmeshed in the clothing shows great promise. This, combined with a new method of estimating the range at which the shot was fired, may be of very considerable medico-legal importance. An adaptation of the new method provides for the firing of test or control shots on a specially prepared curved surface which represents the natural curves of the human body at the site of the wound, and which reproduces the elasticity of natural skin.

Apart from the pure sphere of expert knowledge of arms and ammunition there is also a wide field of usefulness where the expert may be able to assist the medical witness. There are points to be drawn from the area of dispersion of unburnt grains of powder which may be vitally important. The slayer may claim that he was struggling with the victim when his arm went off. The expert can often tell not only the probable distance at which the arm was fired, but may even indicate factors which will disclose the relative position of the two men when the shot was



PRISM ILLUMINATOR
for obtaining equal shadowless light on both sides of an object to be micro-photographed.

fired. Frequently his knowledge of general conditions ruling the performance of firearms in the hands of unskilled individuals may serve to clear aspects of a case which otherwise seem obscure, or may lead to false interpretations. Above all, the expert, although called by one side or the other, is of necessity an impartial witness stating the facts and making clear the scientific mechanism and reasoning which lead to their true interpretation.

POISON GAS AS AN AID TO AGRICULTURE.

ONE sinister legacy of the recent war is being turned to good account in America, namely, the use of poison gas—scarcely a weapon, one might think, that could be turned into a ploughshare, but so it is. General Fries, head of the U.S. Chemical Warfare Service, has recently completed arrangements with the chemical staffs of certain U.S. Government departments for a co-operative research into the effects of poisonous gases on the boll-weevil, the pest that is rapidly ruining America's cotton trade. Furthermore the General's recent success in combating influenza germs by a small percentage of chlorine (first used against the Canadians at Ypres in 1915) in the atmosphere has emboldened him to suggest to the U.S. Secretary of Agriculture that it might be beneficially employed to combat the dread cattle scourge, foot-and-mouth disease.

English Place-names and their Pronunciation.

By Allen Mawer, M.A.

(Professor of English Language and Philology in the University of Liverpool. Director of the Survey of English Place-names).

What should be our rule when pronunciation comes into conflict with the spelling of place-names? This article not only gives authoritative guidance but will probably show that you have been guilty of gross mis-pronunciation in the past.

THE problem of the pronunciation of the English language is an ever-present one, and it has been made more urgent within the last fifty years by the development of universal elementary education. A national system of education must lead here, as in other countries, to a pronunciation of our language which will approximate more or less definitely to that type commonly known as Standard English. The degree of approximation will differ greatly. Most of those who attain some kind of secondary education speak what has aptly been called "Modified" Standard, i.e., Standard English more or less definitely coloured by dialectal peculiarities of pronunciation. Many of those who do not get beyond the elementary school are either bi-lingual, i.e., they speak dialect to their own people and Modified Standard where they think it will be expected or appreciated, or else they continue, at least when the school influence fades away, to be frankly dialect speakers, though, of course, not unaffected by standard speech usage.

The Printed Word.

A system of education which has at most but fifty years of history behind it has not had time to get very deep, and its instruments are themselves often but imperfectly educated. Among the firstfruits of an imperfect education one of the commonest is an undue reverence for the printed as against the spoken word, and this has had important results in leading to such artificial pronunciations as *fore-head* for *forrid*, *waist-coat* for *wesket*, *know-ledge* for *nollidge*. Natural and historic methods of speech have been given up in favour of artificial and erroneous ones in the belief that the new ones are more correct. There has been a good deal of discussion of these problems by Wyld and others, both from the historical and the practical point of view, but hitherto little attention has been paid to the allied but, as the present article will attempt to show, slightly different problem of the pronunciation of our place-names

We are all of us aware of that problem in its crudest form, viz., that there are certain English place and personal names which are veritable traps for the unwary, e.g., *Cholmondeley*, *Marjoribanks*, *Belvoir*, *Beaulieu*, *Rievaulx*, pronounced as *Chumley*, *Marchbanks*, *Beaver*, *Bewley* and *Rivers*, and anyone who pronounced them as they are spelled would be put down at least as ill-informed, if not as ill-educated. Here there is really no problem for there is but one pronunciation, but other names present much greater difficulties. Thus one must at times frankly admit that two pronunciations are commonly heard, and from the lips of those whom one must regard as speakers of good English, e.g., *Cirencester*, *Tynemouth* or *Shrewsbury*, which may be pronounced as spelled, or as *Sissiter*, *Tinmouth* and *Shrowsbury*. Or, again, there are cases where, side by side with a common spelling pronunciation, there exists a local pronunciation which is certainly the more historic one, e.g., *Oany* for *Olney*, *Alemouth* for *Alnemouth*, *Tidzer* for *Tideswell*, *Sapser* for *Sawbridgeworth*. Or we may have convincing evidence that until a few years ago one of these historic pronunciations was in existence but can now no longer be traced, e.g., *Stockenchurch* for *Stokenchurch*, *Ivver* for *Iver*, though one mentions such with diffidence for local pronunciations are often very difficult to recover at least from the lips of the people themselves, and may still exist even though they elude the most careful inquiry. What is to be our attitude towards these more difficult cases?

False Standards.

Before we attempt to answer this question it will be well to consider one objection which has been raised against any attempt to do anything but accept the new spelling pronunciations. It has been said "You are making every effort to train the youth of the nation to abandon dialect and to speak Standard English. Why encourage them to use pronunciations of place-names which will at once reveal their local provenance and handicap them just as much as dialectal speech may?" The main line of reply to this objection is that it fails to realise the difference between ordinary words and place-names. Every common word in our language

has two pronunciations at least—that which belongs to the locality in which the speaker is born, and that found in Standard English, for, artificial though it often is in origin, there is such a thing as a standard of spoken English. So far as place-names are concerned, however, in the vast majority of cases there is really but one pronunciation, viz., the local one. The relatively small minority consists of those place-names which are of sufficient importance to be in such frequent use by the average speaker of English that a Standard pronunciation has been established. Just as one would not expect an educated Englishman to pronounce *Paris*, *Berlin* and *Cadiz* after the French, German, and Spanish fashion, but as they have come to be pronounced in Standard English, so one can have no quarrel with the Englishman who talks of *Birmingham*, *Rochdale*, and *Newcastle* rather than *Brummagem*, *Ratchder*, and *Newcassel*, much as the Standard pronunciation, of say *Newcastle* as *Newcahstle*, may jar upon the ear of the local man. The case is very different, however, when we come, let us say for example, to *Clive* in Shropshire, *Debach* in Suffolk, *Eddlesborough* in Buckinghamshire. Here the only pronunciation which exists is the local one—*Cliv*, *Debbidge*, *Edgeborough* in these particular cases, and to assert that there is any other is linguistically as false as if one took a French book and insisted that the French must say *chair* like English *chair* because it is spelt the same, and entirely overlooks the fact that a word can only have a Standard English pronunciation if it occurs in the Standard speech, and it is no insult to these places to say that not one in a thousand Englishmen is likely ever to have occasion to use their names even once in his lifetime. Our main line of reply to the objection must be then that there is, strictly speaking, no choice in the matter. There is only one pronunciation of the great majority of our place-names. Any other is a false creation of quite modern times based upon the bad principle that English is to be pronounced as she is spelled.

Having established our position we can, however, safely make certain concessions. Local pronunciations are of two kinds—those that depend simply upon giving the local dialectal value to the ordinary English vowels and consonants, and those which show sound developments of a wider character. There is no great point in preserving such local pronunciations as *Poodzer* for *Pudsey*, *Arston Clinton* for *Aston Clinton, or Ookham* for *Oakham*, *Oodersfield* for *Huddersfield* or *Vollaton* for *Follaton*. The student of language has ample other evidence for the existence of such dialectal peculiarities. Neither need we be greatly concerned over *Barrel* for *Barwell*, *Belzerdine* for *Belswardine*, *Wesson* for *Weston*, or *Carditon* for *Cardington* being lost, for the local pronunciation in these cases depends upon developments in colloquial English pronunciation which are of universal occurrence. But that is as far as we can go, for to go further means, as we have seen, admitting a wholly false standard of pronunciation and, what is equally important, the deliberate destruction of linguistic evidence of the greatest historical interest.

Clipped Speech.

Wherein its interest lies, a few illustrations will serve to show. Ordinary English words, as used by the average Englishman, are seldom more than two or three syllables long. Place-names show us what the Englishman does when he has to pronounce a polysyllable, if he is not hampered by learned traditions. He says *Windham* for *Wymondham*, *Pahnzer* for *Pampisford*, *Cunzli*, for *Coniscliffe*, and from a study of these and like names important conclusions can be drawn as to the influence of stress upon English word development. Local pronunciations alone reveal the peculiarity found in East Sussex and West Kent, whereby the final and not the initial syllable is accented in the pronunciation of many place-names, such as *Beddinghám*, *Seafórd*, *Ardingly*, *Eastbóurne*. Local pronunciations of such place-names as those ending in *-ingham*, almost universally in Northumberland and occasionally elsewhere, as though they ended in *indgem*, or of *Ratlinghope* as *Ratchope*, are our chief evidence for the existence in Anglo-Saxon of patronymics with a different suffix from that normally found. The history of a place-name can often only be satisfactorily established if we know the local pronunciation: *Burwash* from O.E. *burh-ersc*, *'earsh* (i.e., stubble-field), by the *burh* or fortified house, only becomes possible when we know that the place is not called *Bur-wash* but *Burrish*. The history of *Turweston* from O.E. *Thurulfes-tun* only becomes clear and credible when we realise that the local pronunciation is *Turstone* or *Tusson*, and that *Turweston* is purely a spelling pronunciation.

Our attitude then towards these local pronunciations must, with the slight but important concessions noted above, be one of the utmost conservatism. Otherwise it is clear that we are guilty of two unpardonable offences. The first is the offence against good speech of using pronunciations which are artificial and truly uneducated, the second is an offence against scientific truth when by our speech-usage we become parties to the suppression of historical evidence.

Rotifers.

By Sir Arthur E. Shipley, G.B.E., F.R.S.

Make them like unto a wheel.—Psalm 83, v. 13.

If you have not got a microscope this article will make you want to get one. If you get one you will never regret it, for it is the key to a new world of infinite beauty and interest.

"On the Somersetshire side of the Avon, and not far from Clifton, is a little combe, at the bottom of which lies an old fish-pond.

"Its slopes are covered with plantations of beech and fir, so as to shelter the pond on three sides, and yet leave it open to the soft south-western breezes, and to the afternoon sun. At the head of the combe wells up a clear spring, which sends a thread of water trickling through a bed of osiers, into the upper end of the pond. A stout stone wall has been drawn across the combe from side to side, so as to dam up the stream; and there is a gap in one corner, through which the overflow finds its way, in a miniature cascade, down into the lower plantation."

* * * *

"But if, retaining sense and sight, we could shrink into living atoms and plunge under the water, of what a world of wonders should we then form part! We should find this fairy kingdom peopled with the strangest creatures: creatures that swim with their hair, and have ruby eyes blazing deep in their necks, with telescopic limbs that now are withdrawn wholly within their bodies and now stretched out to many times their own length. Here are some riding at anchor, moored by delicate threads spun out from their toes; and there are others flashing by in glass armour, bristling with sharp spikes or ornamented with bosses and flowing curves, while, fastened to a green stem, is an animal convolvulus that by some invisible power draws a never-ceasing stream of victims into its gaping cup, and tears them to death with hooked jaws deep down within its body."

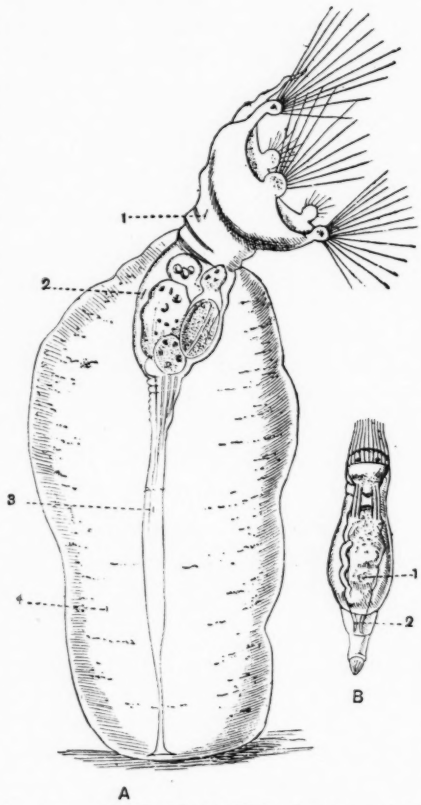


Fig. 1.—A. FLOSCULARIA CORNUTA. Female magnified. From Hudson. 1. Head. 2. Trunk. 3. Foot. 4. Gelatinous tube in which the animal lives.
B. F. CAMPANULATA. Male magnified. 1. Vesicula seminalis 2. Penis.

These lines are taken from the introduction to the classical monograph on the *Rotifera* by Hudson and Gosse, and yet people say men of science cannot write English! They introduce us to the study of a number of small animals which are infinitely more complex than the unicellular protozoa which we have hitherto been considering.

The Rotifera are a somewhat isolated group, and their affinities are obscure. Some of them are just visible to the naked eye, though many of them are but 0.2 or 0.3 of a millimetre in length, and others, especially the males, are much smaller. The very great majority of them are found in fresh water, very few being found in the sea. Some of them are permanently anchored, their body being produced into a stalk which adheres to some substratum. But most of them swim actively about by the action of a loop of cilia at the front end of the body. The action of the cilia produces the appearance of wheels going round, and the early observers in the seventeenth century thought they carried wheels: hence the name of the group. There is a distinct alimentary canal which opens in front by a mouth which comes within the loop of cilia. The other end generally opens near the lower part of the body.

The whole animal is enclosed in a more or less firm, elastic cuticle, and as part of the outside of the body is tucked in to form the mouth the cuticle also goes in with it, and here it is thickened to form two horny jaws which crush against each other and tear to pieces the minute animals and plants, brought towards the

mouth by the action of the cilia. These jaws form the "mastax."

Rotifers are singularly beautiful little animals, and it seems a pity that their "glory should be concealed" from all those who have not a microscope at their command. One of the most grateful and beautiful of them is termed *Floscularia cornuta*, which is very

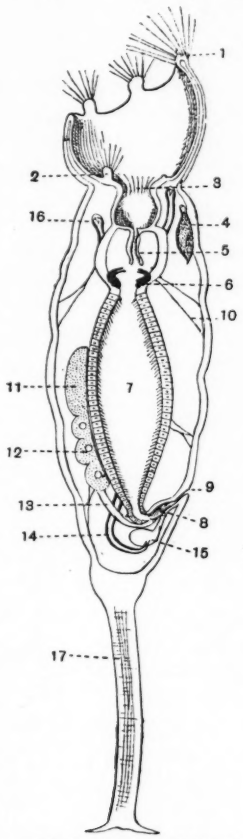


FIG. 2.—DIAGRAM OF FLOSCULARIA.

1. Circle of tentacles bearing bristles. 2. Outer ring of cilia. 3. Mouth leading to vestibule. 4. Brain. 5. Oesophagus hanging like a funnel into the crop. 6. Mastax with jaws. 7. Stomach. 8. Rectum. 9. Opening of Cloaca. 10. Strands of muscles. 11. Yolk-gland part of ovary. 12. Ovarian part of ovary. 13. Oviduct. 14. Excretory duct opening into 15, urinary bladder. 16. A tag with a tuft of cilia. 17. Longitudinal and circular muscles in foot.

widely distributed in our ponds, ditches and pools. To protect itself it secretes a gelatinous tube into which it can retreat when exposed to attack. At the base of the stalk are two large glands which secrete the sticky substance which serves to anchor the little animal, for *Floscularia* is a fixed form, "sessile" as the zoologists say. Its front end is produced into a funnel-shaped cavity which at equidistant points supports five bunches of bristles, which act as a trap for small animals and plants. At the bottom of the funnel is the mouth. Around the mouth is a horseshoe-shaped loop of cilia whose action produces a tiny whirlpool, dragging down into the gaping mouth the numerous minute organisms which form the food of the *Floscularia*.

As sometimes happens in certain groups of animals, the outer layer of cells, known as the ectoderm, have their surfaces undeliminated. They have fused together in a common sheath of protoplasm. Scattered through this layer of protoplasm are a number of nuclei. Within the ectoderm and surrounded by it is a cavity full of watery fluid with no corpuscles, and in this float the more important organs of the little creature. In most animals there is a packing tissue in which the various nerves, muscles, glands and cells are embedded, much as pottery in a crate is embedded in straw. But in Rotifers this packing or "connective-tissue" is at a minimum, and one can generally see with some clearness each individual cell. One can even count them, for they are not very numerous, at the outside many hundreds or a few thousands which, compared with the millions and millions that go to make up the body of larger animals, seems a very small number. The muscles are not banded together, but consist of isolated strands whose chief duty is to withdraw the anterior end into the body when in danger, and to bend the body in various directions. The recovery is effected by the elasticity of the cuticle.

Their Food.

Rotifers feed largely on protozoa and minute plants which are floating about in the water and are caught up in the whirlpool developed by the cilia. This food is passed down into the mouth and ground up by the jaws mentioned above. These jaws are often very complicated. The whole structure is called the "mastax," which is one of the most characteristic organs of the Rotifera, and its presence helps to differentiate them from other groups of the animal kingdom. In a few the mastax can be pushed out through the mouth, and it is then used to cut away part of the tissue of larger algae upon which these Rotifers browse.

Beyond the mastax the food enters the stomach, which is lined with cilia whose flickering presses the food onwards. There are two salivary glands and, in many cases, two gastric glands which open into the alimentary canal. The stomach ends in a simple tube or rectum which also receives the products of the genital and excretory systems. The latter consists of two longitudinal ducts which pierce a column of cells. Communicating with these are a number of tags or so-called ciliated cells. The two ducts in *Floscularia* communicate with one another at the front end of the body by means of a transverse loop.

At the other end they both open into a capacious bladder which contracts at intervals and expels the waste nitrogenous matter, which it has accumulated from the fluid in the body cavity, into the rectum and so out of the body. The excretory organ is a very active organ and in some species the bladder expels a bulk of fluid equal to the bulk of the whole animal every ten minutes or so. This fluid must be replaced by water which soaks in through the skin, and doubtless brings with it oxygen for respiration, for there are in Rotifers no gills or lungs. The excretory organs carry off the carbon dioxide given up by the tissues.

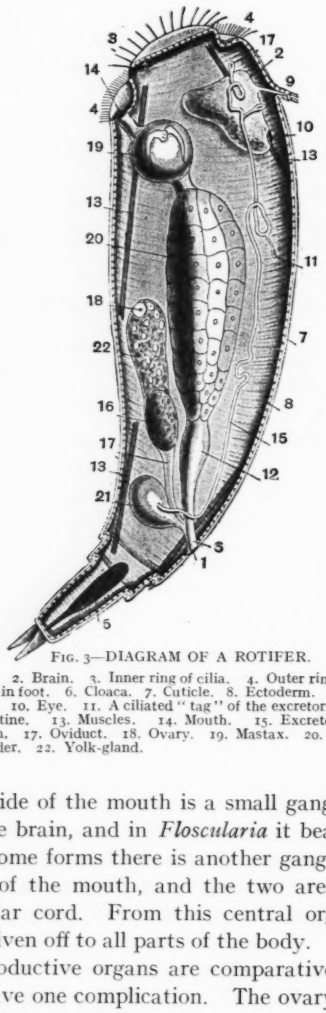


FIG. 3—DIAGRAM OF A ROTIFER.

1. Anus. 2. Brain. 3. Inner ring of cilia. 4. Outer ring of cilia. 5. Gland in foot. 6. Cloaca. 7. Cuticle. 8. Ectoderm. 9. Dorsal antenna. 10. Eye. 11. A ciliated "tag" of the excretory system. 12. Intestine. 13. Muscles. 14. Mouth. 15. Excretory tube. 16. Ovum. 17. Oviduct. 18. Ovary. 19. Mastax. 20. Stomach. 21. Bladder. 22. Yolk-gland.

On one side of the mouth is a small ganglion which is called the brain, and in *Floscularia* it bears two red eyes. In some forms there is another ganglion on the other side of the mouth, and the two are connected by a circular cord. From this central organ nerve-fibrils are given off to all parts of the body.

The reproductive organs are comparatively simple, but they have one complication. The ovary does not, as in a chick, provide the yolk and the female reproductive cell or egg as well. It only gives rise to the latter. The yolk is derived from a different gland known as the yolk-gland. There may be one or two ovaries and one or two yolk-glands. Each is enclosed in a membrane which is continued into an oviduct or a yolk-duct, and these, as we have said above, opens into the rectum just behind the opening of the excretory duct. Through this the eggs, now surrounded by yolk and enclosed in shells, leave the body of the mother and pass into the surrounding water.

Rotifers exhibit a very marked sexual dimorphism and, in the case of *Floscularia* the male is, as is usual in the invertebrates, much smaller than the female. All its organs are reduced and its mouth and alimentary canal have disappeared altogether. They simply do not exist. Most of the interior of the male is taken up by the testes, which produce the spermatozoa. These are injected into the cloaca of the female in some Rotifers, and there the egg is fertilized. In other cases they are introduced at any part of the body wall and then the spermatozoa probably fertilize the eggs whilst still in the ovary.

Like many of the smaller fresh-water animals, *Floscularia* lays two kinds of eggs, in fact even three. During the summer there are (*i*) large eggs averaging five to eight in number which accumulate between the stalk and the gelatinous cyst. These give rise to females. There are, moreover (*ii*), smaller eggs, some eighteen to twenty in number, which turn into males. The production of these seems to be more or less dependent on the temperature. Both these large and small eggs develop without any fertilization, but towards the autumn the third kind of egg (*iii*), known as the winter egg, turns up. These eggs are invariably fertilized ova and are thus produced sexually. They are covered with a thick coat or shell which is capable of withstanding the effects of cold and drought. They live through the winter, when the adult Rotifers are apt to die down and disappear. In the following spring, as the weather warms, they give rise to the normal female which soon starts producing parthenogenetically—i.e., without fertilization—the larger and the smaller eggs.

The class Rotifera is not a very large one. Between 700 and 800 species alone are recognized and about one-tenth of these inhabit the sea or brackish water. A very few are parasitic and one species, *Synchaeta baltica*, floats on the surface of the water and is phosphorescent. Some of them can survive being dried up for a long time, the body shrinking and sealing itself up in its cuticle. They can thus be sent about, hidden amongst dried roots or leaves or mosses, from all parts of the world, and brought to life again in the laboratory by soaking them in water. Apart, however, from these forms, Rotifers, especially male Rotifers, are short-lived.

An Attempt to Break Down the Structure of the Atom.

By T. F. Wall, D.Sc., D. Eng., Assoc.M.Inst.C.E., A.M.I.E.E.

Here is the author's own authoritative account of his experiment which is still proceeding. It is one of the most interesting scientific developments of the year and if success attends his efforts it may mark the beginning of the new epoch when mankind will be able to use atomic energy.

For a considerable time past there has been a well-founded belief that locked up in the atomic structure of the elements are vast stores of energy which, if released and suitably controlled, would be more than sufficient to do all the manual work of the world, drive all the machinery, and render coal and oil practically obsolete as fuel.

To release this atomic energy is one of the most fascinating problems which could present itself to the scientific engineer and the knowledge of the immense and immeasurable practical possibilities makes it a problem not only of the most absorbing scientific interest, but also of the most supreme national importance. In fact it is probably no exaggeration to say that if the solution is within measurable distance the matter becomes without exception the most important of all national problems.

DOCTOR T. F. WALL, D.Sc., D.Eng., A.M.I.E.E.

Before proceeding to describe the attempt to disrupt the atom which the author has planned and is now putting into operation, it may be of interest to inquire as to what at present are the generally accepted facts regarding the constitution of the atom.

The intensive research work which was commenced in the latter part of the nineteenth century in the Cavendish Laboratory of the University of Cambridge, and continued there and elsewhere with unabated zeal and with extraordinarily fruitful results, has led to conclusions regarding atomic structure which may be briefly summarised as follows.

An atom of any element comprises a minute nucleus of positive electricity and one or more electrons (that is, unit charges of negative electricity), which circle round the nucleus like moons round a planet. An atom of hydrogen, for example, in its normal state comprises a nucleus of one unit positive charge and one electron revolving round it at the enormous speed of something like 1,500 miles per second. An atom of the metal mercury comprises a nucleus with an effective charge of eighty positive units and eighty electrons circling round the nucleus in their respective orbits. An atom of gold contains a nucleus formed of an effective charge of seventy-nine positive units of electricity and seventy-nine electrons.

The electrons of the atoms of all substances are identical in every respect. The nature of the element to which any atom belongs depends on the structure of the nucleus, that is, upon the amount of the effective positive charge of which the nucleus is composed. If the amount of this positive charge can be changed, the nature of the element is correspondingly changed. Thus it is believed that Prof. A. Miethe, in his recent experiments at Charlottenburg, has transmuted mercury into gold by the discharge of an intense electric current through mercury vapour contained in an exhausted vessel. There seems to be no reason whatever to doubt that the transmutation has been actually accomplished by Prof. Miethe. It is believed that a number of the atoms of the mercury vapour have each been penetrated by an electron from the stream of electrons which forms the electric current and, in this way, the effective positive charge on each nucleus of the mercury atoms has been reduced from eighty to seventy-nine, with the consequence that *the metal mercury has been transmuted into the metal gold.*

If an electron, say near the inner portion of the atom, is expelled out of its path, a large amount of energy would in consequence be released. If the nucleus itself can be attacked and disintegrated, the whole of the atomic energy would thereby become available.

The author's attempt to disturb the electronic structure of the atom is based on the fact that the electrons speeding round in their orbits are equivalent

to electric currents and, in consequence, give rise to magnetic fields within the atom. These inherent atomic magnetic fields are very intense—much more so, in fact, than any fields which it has been found possible to produce hitherto by artificial means. In accordance with the well-known principles of electro-magnetism, if it is possible to produce artificially magnetic fields of sufficient intensity, and if these artificially produced fields are impressed on the atoms of a substance, the electronic orbits will be disturbed. If the impressed fields are sufficiently strong, the atomic structure of the substance may be permanently altered, so that the physical and other properties of the substance become entirely changed.

When an electron moves in its orbit round the nucleus of the atom, then if a magnetic field be impressed on this orbit in a direction perpendicular to the plane of the orbit, the effect will be that the normal motion of the electron will be disturbed so that, in accordance with Lenz' Law, the disturbance will itself produce a magnetic field which opposes the establishment of the artificially impressed field.

The effect thus produced is now recognized as giving rise to the *diamagnetic* properties of certain substances (notably bismuth) which, when placed in a magnetic field, actually produce a definite and measurable weakening of the impressed field.

In bodies which are powerfully " magnetic " such as iron, cobalt, and nickel, it is generally accepted that the special grouping of the electrons revolving in the atoms produce the magnetic fields which enable such bodies to exhibit the phenomenon of " magnetism" to such a marked degree. In other words, a magnet is such entirely by virtue of the electronic structure of the atom.

Now, if it is possible to produce artificially, very intense magnetic fields which, although not so strong as the inherent magnetic fields due to the revolving electrons in the atoms, are yet of a comparable order of magnitude, and if these intense artificial fields are repeatedly applied to and removed from the atoms of the material, it is reasonable to suppose that although a single application may not produce any appreciable electronic disturbance, a repeated application may produce a cumulative action so that eventually the effect may be both large and permanent. An analogous case is that of a navvy breaking a boulder of rock with a relatively light hammer. The first blow which he strikes produced no visible effect, nor does the second, third, fourth, etc. Eventually, however, he gives the last blow and the massive boulder is shivered to pieces. This is one example of a very common occurrence in which a relatively small force, repeatedly applied, produces an effect which, at first sight, would appear to be out of all proportion to the result eventually achieved.

In order to obtain any reasonably marked effect on the electronic orbits by means of externally impressed magnetic fields, the strength of the field must be enormously greater than anything met with in ordinary practice. The density of the magnetic fields used must be at least of the order of one million units (that is, 10^6 *gauss*).

The practical difficulties in artificially producing magnetic fields of this very great strength are very considerable. For reasons which need not now be entered into, the use of an iron core electro-magnet is not a practicable arrangement for generating magnetic fields of an intensity greater than about 100,000 gauss. Another way, however, of obtaining magnetic fields artificially is to pass a current through a cylindrical coil of wire (technically known as a solenoid). For instance, in a particular case a solenoid was wound with twenty turns per centimetre length, the wire being of diameter 0.06 in. and the resistance

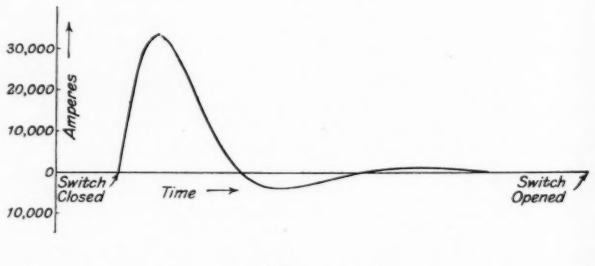


FIG. 2.
SHOWING CURRENT DISCHARGE THROUGH SOLENOID.

of the coil being 0.1 ohm. In order to produce a magnetic field of strength of about 1,000,000 gauss at the centre of this coil, a simple calculation shows that a current of about 40,000 ampères must be passed through the coil. In order to drive this current through the coil a pressure of at least 4,000 volts would be necessary. That is to say, *the power supply to the coil would be at least* 160,000 *kilo-watts or about* 215,000 *horse-power.* When it is remembered that the total power which can be generated by the whole of the

Sheffield Corporation Electric Supply Undertaking is only about 100,000 kilo-watts, this gives some idea of the utter impracticability of attempting to obtain intense magnetic fields by the straightforward method of connecting such a solenoid to ordinary electric generators. The necessary switch-gear alone would be hopelessly complicated, particularly in view of the fact that if the power were supplied to the solenoid for more than a very small fraction of a second, the coil would probably disappear into smoke.

The author's method of coping with the practical difficulty of producing these very intense magnetic fields by means of a current in a solenoid is based on the fact that if the current through the solenoid is only allowed to flow for a very minute fraction of a second, an almost indefinitely large current may be passed through the coil and a correspondingly strong magnetic field produced inside the solenoid. In other words, if a current of I amperes is passed through a coil of resistance R ohms for a period of t seconds the heat generated in the coil will be

$$0.24\ I^2\ R\ t \text{ heat units}$$
(*i.e.*, calories *)

This expression shows that the heat developed is directly proportional to the time for which the current is flowing and directly proportional to the square of the current. If the time t for which the current flows is kept sufficiently small, the magnitude of the current I may be indefinitely large.

In order to supply the coil with a sufficiently large current for a minute fraction of a second, the most practical way is to obtain the current by discharging static condensers. All users of wireless telegraphy apparatus know well that a static condenser is an instrument for storing electricity just as a cistern stores water.

When static condensers are discharged through a circuit of low resistance, the current so obtained is an oscillating one as shown in Fig. 2. At the moment at which the switch is closed the current is, of course, zero, and before the switch is again opened the current has died down to zero again. The switch-gear necessary is therefore reduced to quite moderate and reasonable proportions, since no heavy currents have to be interrupted by the switch contacts.

In Fig. 3 is shown, in diagrammatical form, the arrangement of the apparatus.

An essential feature is a slowly oscillating quick make-and-break switch which is driven through reduction gearing from a small motor. By a special spring device the switch blade is caused to snap over very quickly into its contact positions from one side to the other, two mercury cup contacts being used in conjunction with the switch as shown. When the oscillating switch is dipping into the left-hand mercury cup the high-voltage generator is connected through a buffer resistance to the static condensers, which accordingly become charged. The capacity of these condensers is so great that at least sixty seconds are necessary to enable them to become fully charged. When the oscillating switch snaps over to the right-hand mercury cup contact, the charged condensers are thereby connected to the solenoid in the oil tank and, in consequence, an extremely powerful oscillating current passes through the coil and a correspondingly intense magnetic field is developed in the central part of the core of the coil.

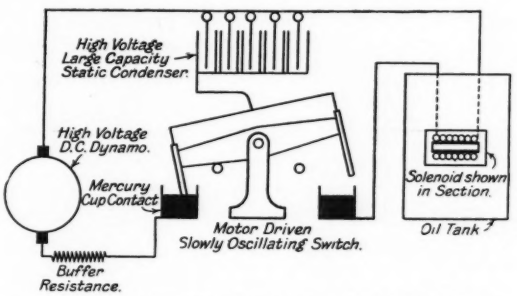


FIG. 3.—DIAGRAMMATIC SKETCH OF ARRANGEMENT OF APPARATUS.

The solenoid coil is wound on a tube and inside the tube may be placed a sample of the material which is to be subjected to the test.

One of the earlier difficulties encountered in this work was due to the mechanical pull on the individual turns of the coil when the powerful currents were flowing in the coil. In one test this pull was so great that the wire of the coil broke whilst the current was flowing. The result was that an explosion of such violence took place under the oil that the tank was ruptured and the oil flooded the laboratory.

By means of the arrangement shown in Fig. 3, currents of the order of 50,000 ampères may be passed through the solenoid winding. An important practical problem is to provide satisfactory means for measuring these very heavy currents and the difficulty is enhanced

*The unit of heat known as the "calorie" is the heat necessary to raise the temperature of one gramme of water through one. One gramme is about one-thirtieth part of an ounce

by reason of the fact that the current flows for only a very small fraction of a second. This difficulty has been solved by the use of the Duddell high-frequency oscillograph which is, in effect, a form of galvanometer with a beam of light as the pointer. The circuit is so connected that a small known fraction of the current in the solenoid coil passes through the oscillograph. When current passes through the oscillograph the beam of light becomes deflected by an amount which is proportional to the current. If a photographic plate is allowed to fall across the path of the beam of light when the current is flowing, a curve such as that shown in Fig. 2 will be traced on the plate, and by suitably calibrating the oscillograph, the magnitude of the current which produces the movement of the beam of light is at once determined. By a special electric contact device operated by the oscillating switch-arm shown in Fig. 3, the photographic plate is caused to fall across the beam of light at precisely the same instant at which the current flows in the solenoid coil.

Intense Field.

The strength of the magnetic field obtainable within the central part of the solenoid by means of the arrangement described, is of the order of some millions of Gauss. By means of the slowly oscillating switch shown in Fig. 3, this very intense field may be impressed an indefinitely large number of times on a sample of material placed in the central tube on which the solenoid coil is wound. The sample may be removed and its magnetic qualities tested at intervals, and any change in its atomic structure will thereby be detected.

The apparatus has not yet been working at its full power for any length of time, but it is anticipated that it will be so working by the time this article appears

In the preliminary investigations at least one remarkable effect has been observed and that is as follows: When the voltage to which the condensers are charged is increased to a sufficiently high value, the current generated when the discharge takes place through the solenoid is very much greater than would be expected from the calculated results. The significance of this effect is important. It means that a kind of instability of the circuit is being produced—the intense magnetic fields produce an apparent decrease of the resistance, this in turn causes an increase in the current and a corresponding increase in the strength of the field, the action being in this way cumulative and leading to very much greater intensity of magnetic fields than could have been reasonably anticipated. The result is being carefully investigated and may lead to applications of far reaching practical importance.

A further incidental result of the investigation is expected with regard to the change of the magnetic properties of magnetic materials. If a permanent improvement in the magnetic qualities of iron, steel, and other magnetic substances can be obtained, the result from an electrical engineering point of view may easily prove to be of outstanding practical value and it is conceivable that it may form the most useful achievement of the whole investigation.

Quite frankly stated, however, the ultimate aim of this undertaking is definitely to disturb the atomic structure for the purpose of releasing some or all of the latent energy of the atom.

In what form such released energy would manifest itself is not yet evident, but presumably it would be in the form of rays of energy of some possibly quite new type. The investigation is thus fraught with the most significant and enthralling possibilities.

Limitless Benefits.

The practical engineering aspect of the undertaking would then pivot on the problem of controlling and directing the released energy for useful purposes. As with all new developments which involve the manipulation of large amounts of power, the possibility of the application to purposes of warfare presents itself. Without stressing this aspect it is obvious that such applications would be of serious national concern. What, however, one would prefer to stress is the application to purposes of industry and human welfare, and such applications would be illimitable.

It is reasonable to presume that if intense magnetic fields are found to be capable of releasing the atomic energy, similar magnetic fields may provide the solution for the control and concentration of the released energy in the form of a ray or beam like the beam of a search-light. If this is found to be practicable, it would probably result in a very simple control apparatus.

Such a ray or beam of energy when directed on any given object would possibly be capable of yielding up its energy in the form of heat, thus superseding the use of coal, oil, or other fuel. What, however, is far more probable, is that new forms of motors would be developed which would be able to use the energy of the beam directly without the need for any intermediate conversion into heat.

BIG BEN.

BROADCASTING gives us not only the Greenwich time signal in "dot seconds," but also the sonorous chime of Big Ben. This clock is quite accurate enough for most people as its error was only one second in two hundred and ninety-three days.

The Human Filter.

By E. V. P.

Physiologists and bio-chemists are paying increasing attention to the essential functions of the kidney. A damaged kidney is one of the organs medical science has not yet learnt to repair. In America a moderately successful attempt to make an artificial or mechanical kidney has produced small but promising results.

THE mechanism of the kidney has long attracted a large share of the attention of physiological experimenters on account of the relative simplicity of the physical principles involved in it. Its function, of course, is to remove from the blood all waste or excess material, particularly that resulting from the breakdown, in the process of digestion, of meat or "protein" food-stuffs. With the strange exception of morphine, and the heavier metals such as lead, in the form of chemical combinations, any substance taken by the mouth can be identified in the urine. It is possible to identify these substances also in the blood-stream; the difference is that they are very much more concentrated in the urine, if they are present at all. For example, urea, which is formed from the breakdown of meat, is normally present only to the extent of .03 per cent in blood, but in the urine it is present up to 2 per cent—it has been concentrated sixty times.

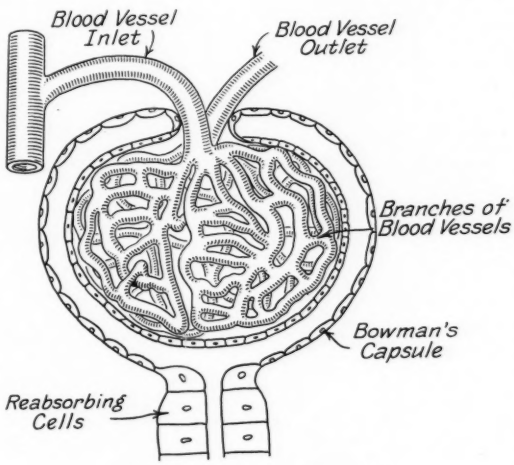


DIAGRAM OF A HUMAN KIDNEY.

On the other hand, sugar, which is always present in the blood, is only present in the urine in diseased conditions.

In other words, the kidney is a filter of a very special kind. Some substances, such as uric acid, are excreted by it in proportion to their presence. But for some other substances—those, in fact, which are useful as food or in the chemical equilibrium of the blood and tissues—are retained in the blood. And finally, the whole of that subdivision of dissolved substances known as "colloids," which are present in considerable quantities in blood, never appear in normal urine at all.

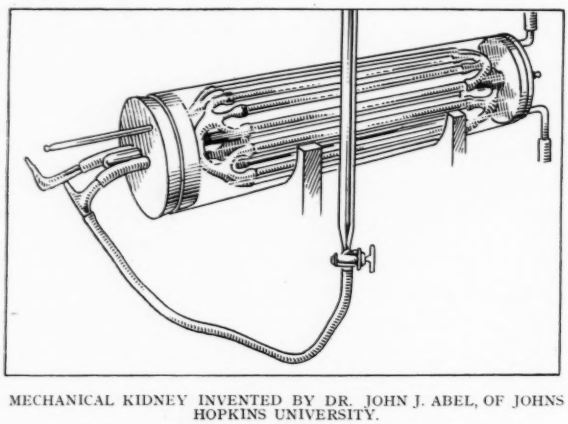
Now if we examine a microscopical section of the kidney, we see that it is well adapted to fulfill its functions as a filter. It is composed of innumerable little tubes, ending in a tuft of blood-vessels enclosed in a little bag, known as "Bowman's capsule." The muscular impulse of the heart is the force which filters the blood through this capsule. The tubes are, moreover, lined with cells which have the power of withdrawing from the fluid which is forced through the capsule, all the items of value to the body. The corpuscles of the blood, and the "colloids" to which we have alluded, remain behind; they are not driven through Bowman's capsule.

So much for the healthy kidney. It is marvellously adapted to all the varying conditions of the body: it retains the useful constituents of blood, and excretes the useless or harmful. But it is very liable to disease and damage. Few patients get over scarlet fever without some damage to it. Advancing age always brings a certain amount of impairment. Certain poisons, such as corrosive sublimate, damage it with fatal results. And, unfortunately, all forms of kidney disease involve destruction of the actual filtering apparatus. Kidney disease, in its more serious forms, is outside the sphere of medical aid. We cannot remake a damaged kidney.

Is there, however, any prospect of providing an additional filtering apparatus? If the sole business of the kidney is to remove poisonous substances, cannot that be done by some physical apparatus? Theoretically it should be possible. It is a simple matter to separate, for example, the organized bodies, the red and white corpuscles, and the "colloids" of blood from the other dissolved substances in it. An ordinary parchment membrane will permit the latter to pass through, and retain the former. That, however, is only one of the functions of the kidney. Such a parchment membrane permits sugar to pass through; the kidney, as we saw,

reabsorbs sugar. It is not easy to conceive a physical apparatus to imitate this essential function.

In practice, definite experimental success has been gained by Dr. J. J. Abel of the Johns Hopkins University in reproducing the filtration function of the kidney. He withdrew the blood of animals from an artery through a glass tube, and passed it through collodion tubes, which were immersed in a warm solution of weak salts. A substance known as Hirudin, derived from leeches, was added to the blood to prevent clotting. Collodion, like parchment, retains colloids, and permits other dissolved substances to pass through it. After a long time, it is found that urea, sugar, and many other substances present in blood can be identified in the fluid on the other side of the collodion tubes. The blood is returned to the artery at the other end of the apparatus.



MECHANICAL KIDNEY INVENTED BY DR. JOHN J. ABEL, OF JOHNS HOPKINS UNIVERSITY.

This device may prove to be valuable as an aid to recovery after certain diseases.

Each collodion tube represents a "Bowman's capsule," though a very inefficient one. But the limitations of the experiment for practical purposes may be realised from the fact that there are two million such filters in each human kidney! Dr. Abel's apparatus, which was a work of experimental genius, and gave invaluable information on the constitution of the blood, would have to be built to the scale of St. Paul's Cathedral if it were to do the work of the human kidney; and even then there would be no allowance for the replacement of essential substances withdrawn, although these could perhaps be added after filtration before the blood is returned to the body. As a permanent substitute for the kidney we would be justified in saying that no conceivable apparatus would suffice. The grafting of healthy kidneys in place of diseased ones is a much more possible development. Many organs have been successfully grafted already; the kidney, however, presents special problems so far unsolved.

But, considered as an emergency arrangement, to relieve the kidneys until they were again capable of resuming their duties after certain acute diseases, a filtration apparatus, while as yet far from being acheived, may well be one of the surgical marvels of the future.

Books Received.

The Study of Living Things. E. S. RUSSELL, M.A., D.Sc., F.Z.S. (Methuen & Co. Ltd. 5*s.* net).

Unknown Tribes Uncharted Seas. LADY RICHMOND BROWN, F.L.S., F.R.G.S., F.Z.S. (Duckworth & Co. 21*s.* net).

Elementary Experimental Statics. A. P. MCMULLEN, M.A., and E. W. E. KEMPSON, B.A. (Cambridge University Press. 8*s.* 6*d.*).

The Structure of Matter. J. A. CRANSTON, D.Sc., A.I.C. (Blackie & Son Ltd. 12*s.* 6*d.* net).

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Farm Accounts. Second edition, revised. C. S. ORWIN, M.A. (Cambridge University Press. 5*s.* net).

Tales from Nature's Wonderlands. WILLIAM T. HORNADAY, Sc.D., A.M. (Chas. Scribner's Sons. 12*s.* 6*d.* net).

Greater France in Africa. WILLIAM M. SLOANE. (Chas. Scribner's Sons. 12*s.* 6*d.* net).

Space and Time. CARL BENEDICKS. (Methuen & Co. Ltd. 4*s.* net).

The Folklore of Bombay. R. E. ENTHOVEN, C.I.E. (Oxford University Press. 14*s.* net).

The Riddle of the Pacific. J. MACMILLAN BROWN. (T. Fisher Unwin Ltd. 30*s.* net).

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Modern Astrophysics. PROF. H. DINGLE. (W. Collins, Son & Co. Ltd. 30*s.* net).

A Shorter School Geometry. Part II. H. S. HALL, M.A. and F. H. STEVENS, M.A. (Macmillan & Co. Ltd. 2*s.* 6*d.*).

The First One Hundred Years of American Geology. GEORGE P. MERRILL. (Humphrey Milford. Oxford University Press. 27*s.* 6*d.* net).

Practical Surgery Illustrated. VICTOR PAUCHET. Vols. I and II. (Ernest Benn Ltd. 18*s.* 6*d.* net each).

Human Psychology as seen through the Dream. JULIA TURNER, B.A. (Lond.). (Kegan Paul. 6*s.* 6*d.* net).

Hairy Plants.

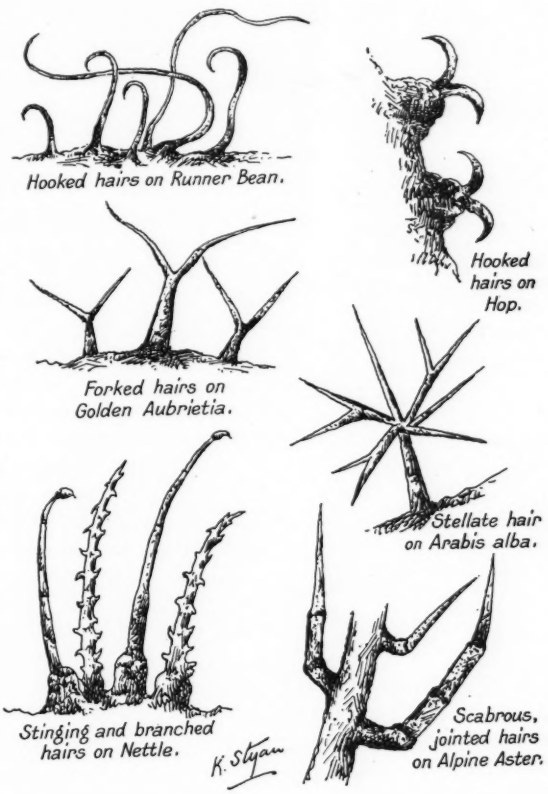
By K. E. Styan.

What do you know about plant hairs? You have noticed them thousands and thousands of times, but have you ever wondered what they were for?

HAVE you ever studied plant hairs? The only things needed for the study are a microscope, spare moments, the love of applied study and a certain amount of skill as a draughtsman, for the charm of the work lies greatly in being able to make enlarged sketches of any curious or interesting hair that shows itself under the microscope.

Before passing on to the many different kinds of hairs met with, let us first see where they may be found on plants, and then what their uses are.

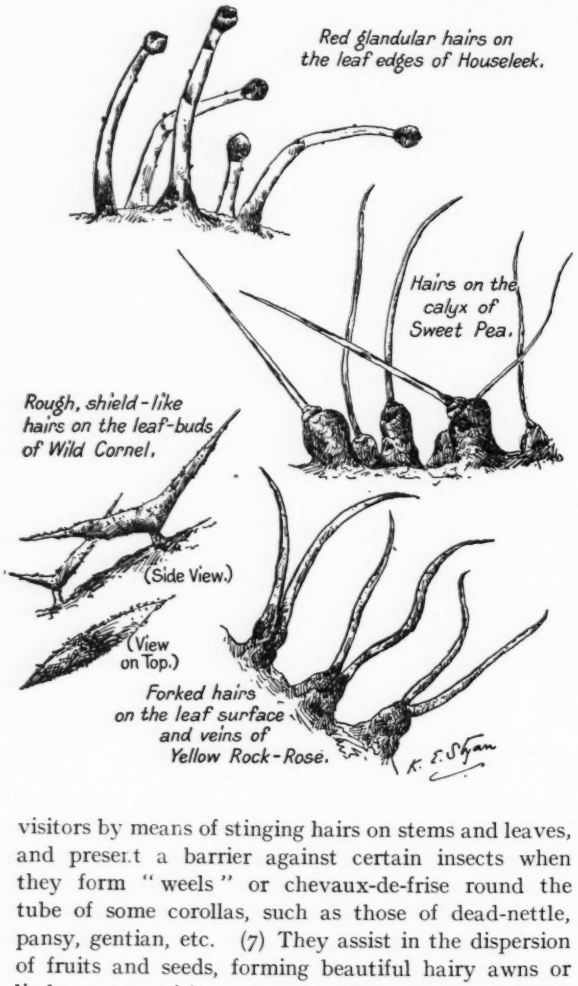
In the first place, they can be found on roots, stems and leaves; on and in calices, corollas, stamens and pistils; they clothe many a bud-scale, many a bract; they envelope many a seed or form an appendage to it; and they are found on fruits and in galls, etc. So—they are not hard to find! But many a plant that looks smooth to the naked eye presents hairs when viewed under the magnifying glass. Don't forget that fact, or you may miss the chance of seeing a good object sometime. The colour differs greatly. Some hairs are silvery white, creamy yellow, pink, blue and other tones of these shades, the coloured examples being found mainly on or in the flowers themselves, or on the main stems. If you look at the glandular hairs on the stem of London Pride and other saxifrages, they look exactly like wee glasses, half-filled with blood-red wine! Charming little objects they are. Then, again, some hairs exude a pleasant, others an unpleasant, odour, some are sweet and others nasty to the taste, many are very glutinous. All these specialities are, of course, intended for special uses, such as for attracting or warding-off agreeable or non-desired insect visitors in search of nectar.


Hooked hairs on Runner Bean.
Hooked hairs on Hop.
Forked hairs on Golden Aubrietia.
Stellate hair on Arabis alba.
Stinging and branched hairs on Nettle.
K. Styan
Scabrous, jointed hairs on Alpine Aster.

Next, as to the uses of hairs. These are somewhat numerous but we will name the most important.

(1) For feeding the plant. Root-hairs and many glandular hairs (as in Sundew and pinguicula etc.) do this. (2) To protect the plant from excess of damp, cold, burning heat, or long drought. Examples for this purpose literally swarm. There are the felted leaves of numerous alpines (edelweiss) and other lowland species; the felted leaves of dry-ground plants such as the cudweeds, the blanket plants of our gardens, the lovely flannelled-leaved and stemmed mulleins of our hedgerows and woods. Rock plants are almost entirely covered with marvellous stellate hairs that protect them from sun and damp and cold, the leaves being specially clothed so that the stomata, or breathing pores, are safe from becoming clogged, frozen, or burnt. (3) Hairs form footholds or "bridges" to large flying insects when they alight on a blossom when seeking honey. These bridges are generally very highly coloured. (4) They play a large part in aiding the process of cross-fertilization, and even self-fertilization. Very wonderful contrivances are found for this purpose in plants, notably in the hairs on the stamens of broomrape and lousewort, and on the styles of the pistils in many vetches, the garden runner-beans and a number of other papilionaceous flowers; also in the large order Compositae (in the daisy, chamomile, feverfew, knapweed, etc.). (5) They assist greatly in the process of a plant's

climbing or adhering to a foreign support, such hairs being forked or curved over at the tip. Ex., the runner bean, cleavers, mugwort, etc. (6) They ward off browsing animals (even man) and unwelcome insect-


Red glandular hairs on the leaf edges of Houseleek.
Hairs on the calyx of Sweet Pea.
Rough, shield-like hairs on the leaf-buds of Wild Cornel.
(Side View.)
(View on Top.)
Forked hairs on the leaf surface and veins of Yellow Rock-Rose.
K. E. Styan

visitors by means of stinging hairs on stems and leaves, and present a barrier against certain insects when they form "weels" or chevaux-de-frise round the tube of some corollas, such as those of dead-nettle, pansy, gentian, etc. (7) They assist in the dispersion of fruits and seeds, forming beautiful hairy awns or limbs, or exquisite pappuses. Everyone knows the silky "thistle-down" and the meadow "clocks" of dandelion and numerous species of the Compositae; also the silky "beards" of the wild clematis. All these are hairy growths that are formed to catch the wind when dispersion is ready to take place. Other beautiful silky-haired contrivances—for the same purpose—can be seen in the wonderful catkins of the black poplar.

The different kinds of hair are :—

(1) Those that are *simple*—that is, without any branchings or outgrowths of any kind upon them. These are made up of one long cell (when we may term them unicellular) or of several (multicellular). Sometimes such hairs are very long and very slender; most delicate and silvery in hue. The webby growth found on many leaves and stems, root-hairs, and countless others are of this form.

(2) Hairs with clearly defined *joints* that resemble knuckles. These are not nearly so common as the others we meet with, but some plants (snapdragon, foxglove, speedwell, hedge-woundwort, artichoke, etc.) are excellent instances of those possessing *jointed* hairs. They can be very well seen also in the hairy tissue that lines the upper edge of the stigmatic surface in many of the orchids.

(3) *The hooked, saw-like, or curved.* Some of these are most curious. If you look at the illustrations of the hairs on the runner-bean and hop you will see how greatly such stiff, curved hairs assist a plant to climb.

(4) *The stellate or star-like.* Of this kind I have found a great number (specially amongst rock-plants), many of which have been most beautiful objects under the microscope. Individually, such a hair has a short or a long pedicel, widest at the base, with a number of rays branching off at its tip. These arms may be simple or branched, and they vary in number in different species of plants. Some have three, others five, six, seven, ten, or many more up to about fifteen. The white arabis has four to six rays, each of which is branched, or some simple and others branched. The "felt" on rock-whitlow grass has stellate, mixed with long branched, hairs, the former bearing usually three rays; lavender shows four to ten-rayed hairs; alyssum nine to eleven; ivy three to nine; some of the hawkweeds show six to twelve; stock shows every variety of number up to about eight. It is owing to the presence of stellate hairs that plants so often show a sort of "bloom" on their leaves (lavender, stock) or a curious roughness (arabis, aubretia, hollyhock, etc.), and this is easily understandable when one sees the myriads of starred hairs that occupy even a wee atom of the plant's surface.

(5) *Forked or barbed hairs* are common and interesting. Beautiful examples are seen in the aubretia and achillea clavennae. The prongs may be two, three, or more in number.

(6) *Stinging hairs.* These are hairs that secrete an acrid, burning fluid in their bulbous bases and eject it into the skin if one rubs against and breaks the glandular tip of the hair. Nettle is a good example.

(7) *Glandular.* These are found in vast quantities on a great number of different specied plants, and afford examples that are extremely quaint, so curious, in fact, that unless one saw them for oneself they might be deemed *unreal*! I have found every con-

ceivable shape and size of glandular hair: long-stemmed ones, others very minutely stalked; some very thick, others very slender; some with most extraordinary bulbs at their bases; some with square or oval tips, others triangular, circular, or brick-like. In some, the whole hair is club-like (sweet-scented geranium), in others the tip is circular and the pedicel flat, and serrated like a tiny leaf; Saxifraga lingulata is a good example of this. These hairs, as the name implies, possess *glands*, either at the base or the tip, which secrete certain fluids that play a leading part in the life of the plant in that they attract or ward off welcome or unwelcome insect visitors, or assist in trapping them and then digesting their nitrogenous properties. In many cases glandular hairs protect developing buds from cold and damp. They vary greatly in colour, scent and taste.

Stinging Hairs.

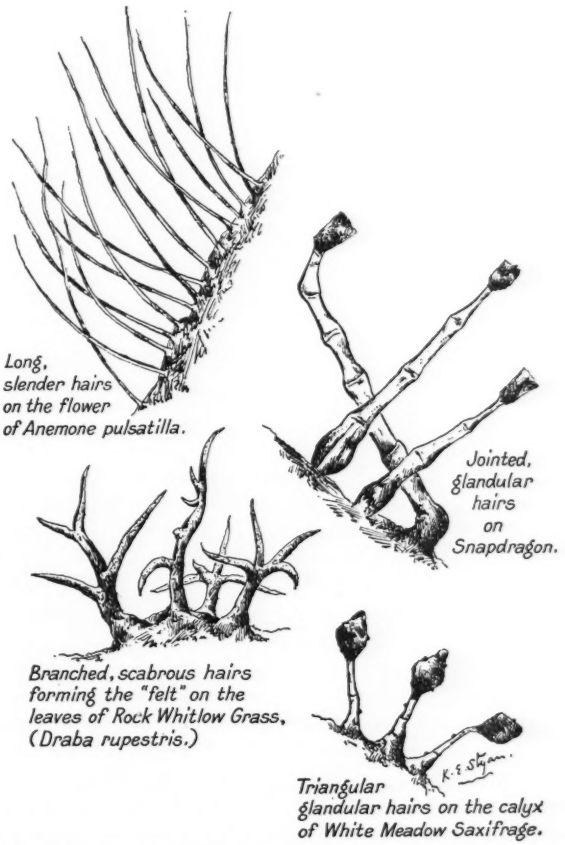
Sometimes glandular hairs grow amongst others of quite another form. An interesting instance of this may be seen in the feathery awn on the ripe seed of the marsh avens. The awn consists of long, exquisitely silky hairs that easily catch the wind and help in the dispersion of the seed, and, secondly, a mass of tiny sticky glandular hairs, which help the seed to adhere to anything with which it comes into contact; this also helps in dispersion. Many saxifrages show two kinds of hairs on their stems, glutinous glandular as well as silky, simple ones, and other examples might be quoted by the dozen did space permit.

Stinging hairs are, of course, glandular, but they are of such distinctive form that I place them in a group by themselves. The name of the order to which the nettles belong is Urticaceae, the word "urtica" being derived from "uro," to burn. The secreted fluid in these plants, specially in several of the foreign species, is very burning, and in some of the E. Indian species is dangerous; the sting of one of the Java nettles in some cases even causes death. In our English species the fluid is secreted in the bulbous base of the hair. This can be seen in the illustration.

(8) *The peltate.* This is a scarce form of hair. Amongst the many hundreds I have examined, only a few examples of shield-like ones have come to light. The best of these were on the under-surface of the leaf of eleagnus. The leaf is very scaly, white and silvery beneath; these scales can be removed with the fingers, and, under the microscope, each is a perfectly wonderful object. It appears as a flatly expanded multicellular structure, more or less circular or square in shape, deeply toothed round the margin, the teeth varying in length. The hair appears ribbed from the centre outwards, and is joined to the leaf epidermis by its centre. It looks like a plate or shield, and is membranous in texture or, as it is correctly called, "lepidote," i.e., scurfy, "lepis" being the name for scurf.

Scurfy leaves are found also in the sea buckthorn, a low-growing local shrub on our east coast, sandy marram covered shores; the leaves of some of the cruciferae, the paleae of young ferns, the wild cornel also show peltate hairs.

As briefly then as possible I have shown some of the peculiarities and interests that can be found in the study of plant-hairs. To my readers I leave it to find out, for themselves, a great many more. Every year adds to my collection of drawings of weird, quaint and beautiful examples, and all hairy plants, in garden or the open "wild," are specially dear to me by reason of the wonders they possess, but which must be examined with care before they can be understood.


Long, slender hairs on the flower of Anemone pulsatilla.
Jointed, glandular hairs on Snapdragon.
Branched, scabrous hairs forming the "felt" on the leaves of Rock Whitlow Grass, (Draba rupestris.)
Triangular glandular hairs on the calyx of White Meadow Saxifrage.

All hairy plants are endowed with a certain amount of mystery. It is open to any student to fathom out that mystery, and enjoy, to the full, the pleasures of the work.

Animal Light and Animal Colour.

By Lancelot T. Hogben, M.A., D.Sc., F.R.S.E.

Little by little the mysterious secrets of the glow-worm, the fire-fly and the chameleon are being explored. Animal light is the most economical form of light in the world. So far it has resisted all attempts to reproduce it for commercial purposes.

In seeking to analyse the behaviour of animals, physiologists have concentrated their attention very largely on two forms of activity which are almost universally distributed in the animal kingdom, and happen to be the pre-eminent modes of response in man and his nearest of kin in the evolutionary scale. These are, of course, muscular contraction and secretion. But animals have many ways of responding to their environment other than active movements and the manufacture of fluid secretions. Among these the production of light and change of bodily coloration are of widespread occurrence among the lower animals, though they do not occur in our nearest allies. Animal light and colour response have always had a picturesque appeal for layman and naturalist; and to-day they are passing from the hands of the naturalist into those of the physiologist, just as the study of muscle is passing from the domain of physiology into that of chemistry and physics.

The Chameleon.

Light production and colour response are associated in the minds of most of us with the glow-worm and the chameleon. Probably few people without a knowledge of animal life in the field are aware that the power to emit light, or to undergo alterations of body colour, is common to a large number of forms belonging to very diverse groups of animals. The first of these, light production, occurs in many fishes, in many of the squid tribe (octopus, cuttlefish, etc.), in a few bivalves such as the rock-borer *Pholas*, centipedes, some beetles and other insects, many of the smaller shrimps and their allies, a few worms, zoophytes and micro-organisms. The majority of these live in the sea, more especially in tropical waters, where occurrence of luminescent organisms of one kind or another often gives the surface a brilliant phosphorescent glow by night.

In some animals a phosphorescent slime is secreted by skin glands distributed over the surface of the body. In others such as the fishes, squids and fireflies the glands are situated deeply in the skin and do not shed the phosphorescent substance to the exterior. Phosphorescent organs of this type are often very complex structures provided like eyes with lenses and even in the case of one fish with a movable lid or diaphragm, by which the appearance of flashes are produced when the creature is given an appropriate stimulus. More usually flash-light effects are produced by the intermittent activity of the light-producing glands themselves. In many instances, however, the manufacture of phosphorescent substances is continuous.

The light produced by living animals is always feeble. It is never sufficiently strong to be visible by daylight, though, as may be easily observed, the phosphorescence of the glow-worm is easily detected by artificial light. Animal light is nevertheless phenomenally efficient. Indeed, in the matter of efficiency no artificial sources of illumination in every-day use can compare with it. All ordinary sources of light are produced, so to speak, incidentally; a good deal of the energy employed is wasted as heat. We obtain light from the electric filament by raising it to a white heat. But the most delicate devices do not detect any appreciable dissipation of heat in bio-luminescence. The rays emitted by the glow-worm or firefly are for all practical purposes a hundred per cent light. Animal light is cold.

Uncertain Value.

Whether the light of the fire-fly is of any use to itself or to others is uncertain. The movement of the horse and the camel, the secretions of the cow and the silk-worm have been turned by man to his own uses. No one has yet made the exploitation of animal luminosity a commercial proposition. Nor is there any immediate prospect that any one will succeed in doing so. One may perhaps surmise that the ornamental possibilities of animal light have not received as much attention as they deserve. That light production assists an animal to prey on other creatures or escape its foes, is largely a matter of speculation, founded on our own predilections and prejudices. At least, it has not been put to experimental test. But the experimental biologist of to-day is less concerned to justify the ways of God to man than to bring into alignment the processes which go on in the animal body, and those with which we are familiar in the realm of inanimate nature. From this angle modern research has to some extent penetrated the darkness of animal light.

In every chemical reaction energy is either given up or taken in, most commonly in the form of heat or electricity. There are, however, a few familiar examples of chemical reactions which involve absorption, as in the case of the photographic plate, or production of light, as in slow combustion of phosphorus in air. Some putrefactive processes which take place in the presence of bacteria—e.g., decaying fish—are of a phosphorescent nature. That the light emitted by an organism like the slow combustion of phosphorus involves the presence of oxygen was one of the interesting biological discoveries which the sceptical chemist, Robert Boyle, made in the seventeenth century with the aid of his air pump. Boyle showed that wood infected with a luminescent fungus ceased to glow when the receptacle was exhausted. And in the succeeding century animal light was removed from the realm of vitalism by the Abbot Spallanzani, whose intrepid curiosity lacking adequate scope in theological controversy provided the germ of more than one biological discovery of first-rate significance. It was he, one may remark in parenthesis, who first showed that the microscopic sperm is the essential constituent of the seminal fluid. Spallanzani proved that the dried and powdered tissues of a phosphorescent jelly-fish would emit light when sprinkled on water in the presence of air. Had this important discovery been made synchronously with the laboratory synthesis of a product of animal or plant activity, a feat which was not achieved till some fifty years later by Winkler, it is highly probable that the work of Spallanzani would have impressed itself indelibly on the thought of his generation. As it was, little further progress was made for a century. Of recent years interest in the subject has been revived through the labours of two workers, Dubois and E. Newton Harvey. The new knowledge that has been gained is worthy of a little attention, for it well illustrates phenomena which are universally characteristic of the chemistry of the living organism.

Time Reactions.

For the purpose of discussion chemical reactions may be divided roughly into two categories—those which take place instantaneously, like the union of an alkali with an acid, and those that require appreciable intervals of time to reach completion. The reactions which take place between organic substances—i.e., the substances which form the bulk of the tissues of plants and animals (living or dead), belong pre eminently to the latter. In practice we can often expedite them by means of substances such as mineral acids which facilitate the combination of the reacting substances without entering into the composition of the end products. Of such chemical lubricants, as one may call them metaphorically, the tissues of animals and plants contain a special group characterised by certain properties—as, for instance, their destructibility by temperatures usually well below the boiling point of water. Technically they are known as enzymes or ferments. It is the presence of appropriate ferments in our digestive juices which enables us to assimilate the constituents of our food. It is the presence of an enzyme or ferment in the yeast plant that enables it to break down sugar with the production of alcohol and carbon-dioxide. The slow combustion of organic substances to which we owe our bodily heat are no exception to the general rule that chemical substances in the body combine under the influence of enzymes, called in this case oxidases because they act as lubricants to the combination of oxygen with the substances derived from our food. In most oxidations that occur in the animal body energy is liberated as heat: bio-luminescence is an example of the oxidation of substances in the presence of an enzyme with the production of radiant energy in the form of light instead of heat.

Practical Application.

Of the precise nature of these substances there is still some doubt. But the extremely minute quantities in which they suffice to produce the glow which is visible to our senses makes one wonder whether their study does not hold out some possibilities of practical application. In biological research it often happens to be possible to learn a good deal about the properties of a substance when it is not accessible in quantities that make chemical analysis practicable. Dubois' contribution to the subject was to show that if two similar watery extracts of the dried tissues of a light-producing animal, such as Pholas, the rock-boring bivalve, are prepared, one being boiled and the other not, the phosphorescence reappears in the latter if some of the former is added after the initial glow has subsided. The experience may be repeated. After the glowing has ceased in the unboiled solution more of the boiled extract added to it revives its power to emit light. The explanation of Dubois' observations is that for light production in the animal body two substances are necessary: one stable to heat combines with oxygen with the emission of light under the lubricating influence of the other which, being an enzyme, is destroyed by boiling. When the lubricant is present light production continues as long as there is any of the oxidizable substance left. When the oxidizable substance is used up the emission of light ceases. But as the lubricant is not itself used up in

the reaction and as the oxidizable substance is not destroyed by boiling, addition of the boiled to the unboiled extract gives the latter a fresh store of the former on which to operate. Substances which remove oxygen (reducing agents) restore the phosphorescent properties of an extract which has ceased to glow.

Like bioluminescence, colour response among animals was known to writers of antiquity, among them Aristotle. Its intimate nature and control has only begun to be understood during the last half-century. Just as animal light is really a particular form of secretion, colour response—the transitory changes in bodily hue which animals display—may be brought about by muscular activity. This is so in one group at least, the octopus and its allies, where the most exquisite diversity and surprising rapidity of change are witnessed. The same cuttlefish can change in the twinkling of an eye from a delicate green to bright orange or purple. The skin is charged with little bags of pigment, of which there may be two or three different kinds (yellow, violet, russet), situated respectively at different depths. They are just visible separately to the eye, and under the microscope each little bag of pigment is seen to be surrounded radially by muscles, whose contraction or relaxation change the capacity of the receptacle and therefore the surface of pigment available to reflect or absorb light of different wave-lengths falling upon the skin. The various tints which are witnessed in the colour change of the squid or octopus result from the varying degrees of expansion and contraction of the pigment bags at different levels. In other animals the flow of pigment in the pigment spots is not brought about by muscles acting on the latter. True colour response, i.e., temporary colour changes that depend on the mechanical distribution of pigment in the skin, as opposed to chemical and structural colour changes resulting from food or climate, exists in reptiles such as many lizards, snakes and chameleons, in amphibia (toads, frogs, salamanders), to some extent in most fishes, and in many crustacea (shrimps and their kind).

An Experiment

To make clear what is meant by colour response in these forms, a simple experiment with the common frog may be carried out as follows. If a frog is taken from its natural surroundings it will generally be found to be of a dull-greenish hue. Placed in a cold shady room in a blackened receptacle containing a little water, it will assume after an hour or more a duskier hue which within two days may give place to an intense black. When the same animal is transferred from these surroundings to a dry whitened vessel placed in a brightly-illuminated and warm situation, it will become within a few hours visibly paler. In two days the tint of the body will be chrome or lemon yellow flecked with darker bands in some varieties. What is actually happening in this series of transformations may be appreciated more intimately by a scrutiny of the web between the toes of the hind leg. Examined with a hand-lens it is seen to be studded with minute specks of black pigment. Closer observation with the microscope shows that each pigment spot is an irregularly star-shaped body with branching processes along which the pigment particles migrate. There are two kinds of pigment cells in the frog's skin, some black (melanophores) and others yellow. When the frog is pale, the black pigment granules are seen to be concentrated in a dense mass at the centre; when the frog is dark they are seen to have migrated outwards along the branching processes which, interlacing with those of adjacent pigment cells, form a dense black network. The reverse is the case with yellow pigment cells which are "expanded" when the animal is pale and "contracted" when it is dark. Watching the changes in a single black pigment cell as the frog turns from black to yellow in outward appearance, we see the migration of the pigment particles inwards towards the centre, so that a diffuse network of pigment gives place first to star-shaped bodies and finally to compact balls of black.

Eyes Essential.

It was the great naturalist Milne Edwards who first appreciated that colour response is brought about by the flow of pigment in the pigment cells. The black pigment cells (melanophores) are the main agents in determining the intensity of colour in reptiles and fishes as well as in the frog and its relations. In fishes there is often considerable rapidity of colour change. A minnow transferred from a dark to a light bottom will become black within a period of three to eight minutes. A flatfish may take from half an hour to a day. In fishes such changes with respect to the nature of the background depend on the organs of vision. The animal does not become pale if placed on a white background when blindfolded. The eyes transmit these stimuli through nervous impulses which travel direct to the pigment cells, since an area of skin to which the nerves have been severed remains dark when the fish is transferred from a dark to a light background. The same explanation was once thought to hold good for the chameleon and the frog. It now seems, however, that the colour changes of these animals are controlled by secretions of the ductless glands circulating in the blood stream.

The responses of the chameleon have been grossly exaggerated both as regards their extent and rapidity ; there is, in fact, a chameleon mythology. Different races of chameleons differ greatly in colour, but the range of tint—e.g., yellow to dark brown or pale green to black—is quite as restricted as in the common frog, in which, however, the slowness of the changes makes them less obvious to superficial examination. Chameleons, lizards and snakes undergo colour change in response to temperature, light and certain harmful stimuli. In the chameleon itself these changes are complete within fifteen minutes to three-quarters of an hour. As with the frog, warmth tends to promote the pallor associated with contraction of the black pigment cells. On the other hand, reptiles respond to light in a manner which is the reverse of that which is characteristic of amphibia and fishes.

A Reversal.

The black pigment cells expand in the light and the animal becomes dark ; in darkness they contract and the animal becomes pale. Both the effects of temperature and illumination can be reproduced locally by stimulating an area of the skin ; the response to light is a direct one on the part of the pigment cells themselves and the eyes have no influence upon it, since blinded and seeing chameleons respond in the same way. When, however, a harmful stimulus, such as a faradic current, is applied to the skin locally, it induces pallor over the entire body. The way in which this is brought about has been studied not in the chameleon itself but in another lizard, the American horned toad. Messages may be transmitted from one part of the body to another not only by nerves, but by the production of substances circulating in the blood and stimulating the organs concerned, when they reach them. Organs which secrete such messengers are known as ductless glands. One of the most important of the ductless glands is the adrenal, lying on each side of the kidney. Its extract has certain characteristic physiological effects, first discovered by Schafer in the 'nineties, and simulating the physical manifestations of fright. It has been shown that fright in dogs and cats is correlated with the liberation of adrenaline, the active substance of the adrenal gland, into the blood stream. Adrenaline has also been shown to produce contraction of the black pigment cells in the lizard, and when the adrenal glands are removed a lizard will no longer become pale in response to the application of a harmful stimulus, though it displays colour change in response to light and heat as before. When the glands are intact, however, pallor ensues even after the nerve supply of the skin has been destroyed, but not locally in a limb of which the blood supply has been temporarily cut off. It thus seems that the nervous impulse set up by a harmful stimulus is not conveyed directly to the pigment cells, but influences them secondarily by stimulating the adrenal gland to secretion. Thus excitement pallor in the reptile is analogous to one aspect of fright phenomena in ourselves.

The most extensive experiments on the physiology of colour response have been carried out with amphibia (frogs and salamanders). In these animals colour response is mainly, if not entirely, controlled by a ductless gland, in this case the pituitary body which lies on the floor of the brain. In frogs and their allies moisture and temperature are more important than light in evoking colour response. The reaction of the pigment cells is in no case direct, the response to light depending upon the eyes. Section of nerves to the skin does not seem to interfere with the normal sequence of colour change. When, however, the pituitary gland is removed the black pigment cells remain permanently contracted ; the animals are persistently pale in the presence of all natural stimuli which cause the normal animal to darken. But the injection of a minute quantity (less than a fifty-millionth of an ounce) of the gland extract will bring about intense darkening of the skin.

The utility of pigmentary changes like that of light-production among animals is problematical. The commonly-accepted, plausible, and unproven view ascribes to pigmentary response a means of protection from or warning to enemies or a cloak of invisibility for marauders. To-day biologists are less obsessed with the almightiness of natural selection and seek for experimental verification before pinning their faith to such doctrines. According to another view the pigment cells are an adjustable screen by which the intake or radiation of heat may be regulated. It is probably true that they do affect the exchange of bodily heat, but that they do so to an extent which has much bearing on the viability of an animal endowed with them is a proposition which it is hard to prove or disprove.*

An underground river passing beneath Mont Blanc and known as Eauxbelles is now thought to pass right through into France. Suitable tests by means of dyes or an identifiable chemical have been suggested as a means of distinguishing its outlet.

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* Further reading :
E. Newton Harvey. "The Nature of Animal Light." Lippincott.
Lancelot Hogben. "The Pigmentary Effector System." Oliver and Boyd.

Mead: The Drink of the Vikings.

By T. W. Jones, B.Sc.

Have you ever tried a drink of mead? It is simple to make and pleasant to drink, and it has a fine literary flavour that goes back to the days before recorded history. Here is the scientific explanation of the rule-of-thumb process evolved by our ancestors.

That Maelgwn of Mona be inspired with mead and cheer us with it
From the mead horn's foaming pure and shining liquor,
Which the bees provide but do not enjoy;
Mead distilled, I praise; its eulogy is everywhere
Precious to the creature whom the earth maintains
God made it to man for his happiness,
The fierce and the mute both enjoy it.

So runs a literal translation of a Saxon saga by the bard Taleissin who, Prof. Saintsbury tells us, lived in Cumberland in the sixth century. The art of brewing the beverage mead from honey is older than the history of the human race; it was the first fermented liquor that man made. It is at all events accepted by scholars that primordial man brewed mead from the washings of the emptied honeycomb, which thus supplied him both with a sweetmeat and the raw material for a beverage with which he might view his naked world through rosier spectacles. At the close of what is known as the migratory period in man's history, he settled upon the land and commenced to plant, sow and reap; he learnt that more potent drinks could be brewed or distilled from such crops as barley, hops, rye, and the vine, and these gradually displaced the humbler mead from popularity; to-day mead is only made in small quantities in country farmhouses in England. In France and Germany there are a few firms that make and sell it, and before 1914 it was quite a popular drink in Russia.

As our primordial ancestors were aware, mead is a beverage that can easily be made by the veriest novice, and with ordinary household utensils. It is, therefore, particularly suited for brewing by the modern housewife, who, in these days of economy and flats, cannot afford the time or space that must be given to the brewing of such beverages as beer and ales, wherein the barley has to undergo long periods of drying and germination whilst spread out upon a floor kept a certain degree of temperature and moisture. All the operations may be carried out in the ordinary kitchen with the ordinary household pots and pans. The only item that may be lacking is a small cask for the final maturing of the brew, and if the brewer pleases this can be replaced by bottles either of glass or "stone" which, however, must be strongly stoppered when filled with the newly-fermented mead.

Before proceeding further we will give a brief outline of the processes which we shall describe more fully in subsequent paragraphs. There are roughly four distinct operations in the brewing of home-made mead. Firstly, the boiling, flavouring and clarifying of the honey; secondly, the addition of the yeast to the honey "wort," as it is called; thirdly, the actual process of fermentation; and finally, the bottling or casking for the maturing process. The labour entailed is small and the result delicious, if we are to believe Taleissin.

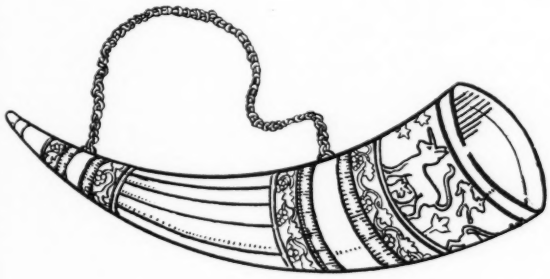
Simple Precautions.

There are certain elementary precautions, however, that must be observed if success is desired in the brewing of mead, and every brewer of beer has learnt by experience that they must be taken in every fermentational process whatsoever, where a certain result is required. Fermentations of starches and sugars to alcohol, more generally known as Alcoholic Fermentation, is brought about by the vital, or life, processes of certain vegetative micro-organisms known as yeasts. In order to do this, the yeast must be maintained in an active and healthy condition, and such conditions are favourable to the flourishing growth of countless other micro-organisms, many of which are inimical to the production of a good mead; certain of them indeed, such as the acetic-acid-forming bacteria, would turn the wort into an inferior form of vinegar—not at all a desirable result. All of these must be excluded and this is done by sterilizing both the wort and all the vessels used in making the brew. Any vessel that is exposed to the atmosphere and contains fermenting liquor, etc., should be kept covered by a thick muslin cover, if a metal or stone one cannot be used. Sterilization is perfectly simple, and consists in boiling the honey for a certain length of time so as to kill any organisms it may contain, and afterwards keeping it covered so that no fresh ones can enter.

This includes the boiling, clarification and flavouring of the honey which, when it is finally ready for fermentation, is technically known as the "wort."

Honey, as everyone should know, is the substance that the bee manufactures from the nectar of flowers and stores in the hexagonal wax cells forming the honeycomb. It is, therefore, a highly complex

substance consisting of a mixture of sugars (about 75 per cent), moisture (about 20 per cent) and the remainder of waxes, gums, starches, colouring matters, and certain complex organic acids and nitrogenous compounds, known as enzymes. In addition to these it usually contains certain yeasts which will set up



ULPH'S HORN.

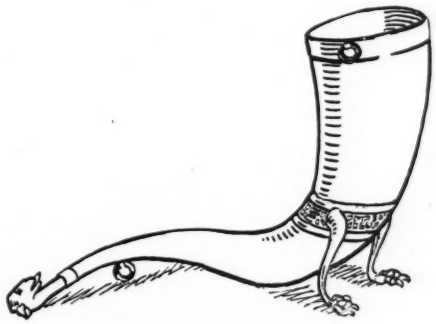
a natural fermentation and must, therefore, be killed before the honey is fit for making into mead. The proportions of all these constituents vary according to the locality, the time of year and the flowers visited by the insects, and upon these depends its flavour: honey made chiefly from the nectar of heather has its own peculiar flavour, for example. The flavour, however, may be modified by the addition of spices, lemon juice, hops, and many others, according to individual taste; such flavouring materials should be added just after boiling is completed and before fermentation commences.

We will take the quantities required for a brew which can be easily handled in the average household; these may, of course, be modified for special purposes, but so long as the proportions are maintained the results should be the same.

First of all is required a large saucepan or boiler that will conveniently hold about eight or nine gallons of liquid. This must be perfectly sweet and clean, for honey is like milk in that it will pick up any contaminating odour; it need not be an old one, since the boiling of honey is quite a clean process and anything left behind after pouring off the wort can be easily washed out. Into this are poured 15 lb. of ordinary expressed honey and seven gallons of boiling water. Soft water, such as distilled or rain water, is the best to use; tap water gives disagreeable colours to the mead since it contains inorganic salts. At a pinch it may be used if previously boiled and filtered. The water is necessary not only to dilute the sweetness of the honey but also that the yeast may act upon it, for dry honey cannot be fermented as the yeast needs water to live. The honey and water are well mixed and the white of two eggs added and the whole vigorously stirred. The white of egg coagulates on boiling the honey and carries down with it the suspended matter such as resins, waxes, small particles of honeycomb and so on, which would render the mead turbid; it therefore aids very considerably in the clarification of the wort. After the addition of the white of egg the honey and water are gradually heated to boiling temperature and kept gently simmering for an hour and a half, any scum that rises being carefully skimmed off.

Sterilization.

This boiling of the honey serves not only to sterilize it and coagulate any suspended matter, but also to ripen it by furthering the action of the enzymes it contains. These are chemical ferments which are derived from the flower and also from the bee during the process of converting the nectar into honey. The two most important enzymes in honey are invertase and diastase, and these act upon the sugars and starches of the honey and convert them into simpler compounds upon which the yeast can act. When the honey is to be artificially fermented the amount of diastase must be reduced since it is possible to have more present than is healthy for the yeast. By boiling the honey for about an hour and a half we can destroy sufficient of the honey diastase, since all enzymes can be destroyed by prolonged heating. When boiling is finished the honey is allowed to cool a little and any flavouring materials added. Most housewives have their favourite flavouring materials for mead, among which we may mention lemon juice, citric acid, nutmeg,



THE PUSEY HORN.

cinnamon, as a few examples. It is generally the custom to add an ounce or so of hops. These fulfil a double role, both flavouring the mead by the bitter tannins they contain, which thus modify the cloying sweetness of the honey, and by helping in the coagu-

lation of suspended matter. After the flavouring materials are added the liquid is again boiled, this time for not more than ten minutes, and then set aside to cool and settle, care being taken to cover it during the cooling.

The " wort," as the boiled honey is termed, is then clarified by straining or filtering through a calico or thick muslin filter; this is held over the fermenting vessel, so that the clarified wort is then ready for the yeast. This vessel may be any boiler, enamel flour bin, or small cask, but it must be perfectly clean and throughly scalded before running in the wort. It should stand in a warm dry place free from draughts and during fermentation should be kept at an even temperature of 70°-80°F. When all the clarified honey wort has been run in the specific gravity must be determined; the easiest way to do this is to put a new-laid egg in the liquid: if it just sinks the wort is right for fermenting; if the egg floats, boiled water should be added until it just sinks.

Fermentation.

The clarified mead is now ready for the addition of the yeast, and there are two ways of doing this, either directly or by means of an intermediate or " mother " ferment. For large brews the latter is to be preferred, since fermentation then takes place more evenly throughout the whole mass; but either method will do for the quantities we are here considering.

The very best way of adding the yeast directly to the wort, when making a small brew such as this, is to toast a slice of bread so that it is a golden brown upon both sides; this is allowed to cool in the oven and then spread with about three ounces of ordinary brewer's yeast as used in making bread. This is then introduced into the bin or cask of wort.

To make an intermediate ferment the same amount of yeast (three ounces) is added to a pint of the sterilized wort in a bottle. (The pint of wort is boiled in the bottle by standing the latter in a saucepan and boiling for a quarter of an hour. The mouth of the bottle should be closed with a plug of clean sterile cotton-wool). After the yeast is added to the wort the cotton-wool plug is replaced and the bottle stood in a warm place at 70°-80°F. for about sixty hours. At the end of this time the yeast should be ready for addition to the main bulk of the wort contained in the fermenting bin or cask, and is thoroughly mixed with it.

Temperature.

After the addition of the yeast to the wort the bin or cask is covered with a close-fitting cap of muslin to keep out any other bacteria or micro-organisms, particles of dust, insects, etc., and at the same time allow air to enter. The temperature must be maintained as evenly as possible at between 70°-80°F. If the temperature gets outside these limits, the yeast will be either killed or damaged so badly that proper fermentation will not take place. The wort is allowed to ferment for a period of ten days to one month, according to the type of honey used and the percentage of alcohol required in the mead. The average brew using these proportions of honey and yeast is completely fermented in a fortnight and the final mead contains about 7-8 per cent of alcohol. The end of fermentation can be easily recognised by the subsidence of frothing, which is most vigorous during the first four or five days. It is possible, by suitably varying the amounts of honey and yeast and by lengthening the period of fermentation, to obtain a higher percentage of alcohol; as much as 29 per cent of proof spirit was obtained in a mead by one German firm before the War. Here, possibly, is an explanation of the remarkable feats recounted by the Norse bards of their heroes: they may have had the secret of an abnormally strong brew.

During fermentation, at all events during the last few days, the fermenting wort is better for a vigorous stirring at least once a day; by this means the yeast is " roused " and aërated.

On the conclusion of fermentation the mead has to be freed of yeast and matured; sometimes it is subjected to a further fermentation with yeast known as the " secondary fermentation." This, however, is unusual in England, although much practised in Germany. The liquor is usually strained through a muslin or similar filter, like that used to clarify the unfermented wort, and poured into a barrel or cask just large enough to hold the brew. Or it may, after straining, which is done to filter off all the yeast cells, be poured into bottles. Whichever method is adopted, care must be taken that the receptacle is scrupulously cleaned by a very thorough scalding with boiling water. The mead should then be allowed to mature for three or four months, but will keep and improve with keeping for a year or more.

NEW LABORATORY MATERIAL.

CRUCIBLES made of pure iron oxide are being tried as a substitute for porcelain. The oxide is prepared from the purest of molten iron, and is cast in moulds. The new ware is said to be very much cheaper than porcelain or nickel, and applicable to a very wide range of ordinary commercial chemical uses.

Are Fishes the Source of Petroleum?

THE origin of oil is one of those subjects which oil experts prefer to leave out of conversation. Sometimes it is a problem that may be quietly and speculatively discussed, more frequently it seems to rouse the worst geological passions, one school favouring a vegetable another an animal origin. There have even been heretics who held with neither school and favoured a mystical and inexplicable theory that oil was purely inorganic in origin. Up to date the arguments for animal origin appear to have had rather more support and now Professor John Muirhead MacFarlane, D.Sc., LL.D., Emeritus Professor of Botany of the University of Pennsylvania, comes into action with two redoubtable volumes, "The Evolution and Distribution of Fishes" (Macmillan, 25*s*. net) and "Fishes the Source of Petroleum" (Macmillan, 25*s*. net).

Fossil Fish Remains.

The first is a very complete survey of the whole history of the evolution of fishes from invertebrate forms and their distribution and development during the succeeding geological epochs. Contrary to many authorities, Professor MacFarlane holds that all organic life began in fresh water, and thence invaded the sea, where under new stimuli and conditions fresh forms were evolved and enormous increase was possible. In support of this argument he points out that the majority of the present-day descendants of the oldest known groups of true fishes are still freshwater types to-day, and that it is only since the Cretaceous and Eocene period that the marine fishes became predominant. Prior to the Cretaceous period 320 living genera are freshwater and 155 marine. To-day 453 living genera are purely freshwater and 902 marine, with occasional freshwater representatives.

It is from this close and careful analysis of fossil fish remains that he builds up a picture of a remote prehistoric world where the continents as we now know them were entirely different in shape and where vast lagoons or shallow lakes were crowded with teeming multitudes of fish.

These colossal fish tanks were overwhelmed by volcanic or other enormous calamities. The fish were killed instantly and their decomposed remains furnish the now vitally important petroleum deposits of the world.

This briefly is his theory and it is no mere idea put forward on the basis of the occasional occurrence of fossil beds of fish bones and scales above oil deposits, but is backed by a thorough and painstaking review of the varieties of fish so associated.

The abundance of fish life during past geologic periods must have been enormous, while their sudden and wholesale destruction at definite periods was enormous. Not merely for miles but even over hundreds to thousands of square miles of the same rock stratum their fossil skeletons are found in dense layers. Where these fishes are of certain definite fat-bearing genera, usually of freshwater origin, the fish-bone stratum is formed in association with oil shales.

Mass Calamity.

The dead fish were in some cases entombed as they lay in heaps or drifts. In other cases the oil set free by decomposition drifted with the waters and was absorbed by clay particles to make layers of oil shales. In process of time these oil strata were crushed and in many cases the expressed oils passed through into porous sandstones and kindred rock formations whose action is thus that of reservoirs rather than producers. Passing from the question of how the fish oil got into the rock to the chemical side, recent research discloses that fish oil properly treated yields all the products formerly thought to be associated only with petroleum. The intermediate coal bodies such as cannelite and lignite down to anthracite show a proportional increase of purely vegetable sources of origin, but in some cases where the original stratum held a proportion of fish as well as plant masses, analysis shows a variation in composition.

Professor MacFarlane roundly sets forth:

"Vegetable remains do not enter into the production of kerogen or crude petroleum which is wholly of animal origin."

"The group of fishes alone in the animal kingdom conforms in every respect to the requirements for the formation of crude petroleum—and is not even approached distantly by any other group of animals."

Whether future discoveries will shake this theory remains to be seen, but for the present it can be said that Professor MacFarlane has made out a strong case based on ascertained fact and careful research that will stand critical examination.

When the threatened exhaustion of the oil reserves comes about, we may yet be forced to turn to the resources of the sea, not for food, but for motive power and all the vast needs for petroleum products in modern industry.

Book Reviews.

The Evolution of Man. Essays by G. ELLIOT SMITH, M.A., M.D., Litt.D., D.Sc., F.R.C.P., F.R.S. (Humphrey Milford, Oxford University Press. 8*s.* 6*d.* net).

This book is sure of a very real welcome for it provides in a most excellently readable form a general guide to the Evolution of Man. It can be as earnestly recommended to the general reader as to the student of anthropology.

An admirable foreword illustrated by diagrams, tracing the tentative relationships of the human family and the order of primates introduces the reader to the general lines of scientific investigation and current theory, and is followed by the first essay, "The Evolution of Man," an address delivered at Dundee in 1912 to the Anthropological Section of the British Association. In it the evolutionary development is traced, not merely from the ape, but right back to a little Lemuroid rather like the Javanese Tarsia of to-day, which lived at the beginning of the Tertiary period.

Chapter II is devoted to Primitive Man. The Neanderthal, Piltdown and Rhodesian skulls are illustrated and fully discussed, as is *Pithecanthropus*, which the author is inclined to class as belonging to a very lowly member of the human family rather than to the apes.

The intellectual and cultural processes of the successive evolutionary steps in Man's long ascent are as carefully explained as the interlinked biological variations.

The last chapter or essay is the lecture on the Human Brain given at the Royal Institution in February this year. Appreciation of the nature of objects and events happening in the outside world did not occur in the ape brain, but this quality of perception only originated when Man's immediate ancestors were assuming human qualities. The attainment of the realisation of space and time marks the transformation from ape to man. Speech as distinct from mere animal cries evoked by emotion followed.

A concise bibliography of books useful as a guide to the student rounds off a book which is in itself a précis of all accepted knowledge and current theories of the Evolution of Man.

Matter and Change: An Introduction to Physical and Chemical Science. By W. C. D. WHETHAM, M.A., F.R.S. (Cambridge University Press. 7*s.* 6*d.* net).

It would seem impossible to have compressed such a full review of the methods and results of modern chemical and physical science into one short volume. The achievement is in itself wonderful, for it presents in simple concise form, not only the content of several shelves of ordinary textbooks, but a clarity of explanation and a simplicity of style that is in itself admirable.

There are many readers of DISCOVERY who would say at once "Just the book I have been looking for!" The title, though excellent in its way, does not however give a proper idea of the book to the particular class of reader it is designed to appeal to.

Here, in one well-illustrated inexpensive volume the ordinary man will find all that he needs to know about Relativity, the electron, the atom and all the vast arcana of new and old facts and laws extracted by science. It is a book that should be on the bookshelf of every educated man, and can be read from cover to cover without more than a knowledge of ordinary school mathematics.

The Home of an Eastern Clan. By MRS. LESLIE MILNE, F.R.A.I. M.R.A.S. (Oxford University Press, Humphrey Milford. 16*s.* net).

Mrs. Milne has been happily able to combine an extraordinarily interesting "travel-book" with a complete and important ethnological study. The book is interesting throughout, not only as a model study of the unknown Palaungs of the Shan States, but for its human interest.

Throughout we see Mrs. Leslie Milne at work as a practical longsuffering ethnologist making a detailed first-hand study of her subject. She writes of her people with the greatest possible insight and sympathy, and quite apart from its very definite scientific interest the book has a particular charm of its own.

The childhood, adolescence and odd marriage customs of the tribe are portrayed with a wealth of detail, and the important and interesting customs of trial by ordeal and the use of magic charms and omens are written of in such a manner that they become no mere record of obscure observances, but interesting and as part of the life and belief of this unspoilt people. An excellent book.

An Introduction to Oceanography. By JAMES JOHNSTONE, D.Sc., Professor of Oceanography in the University of Liverpool. (London: Hodder & Stoughton Limited. Published for the University Press of Liverpool. 15*s.* net).

There are few men more competent to write on Oceanography than Professor James Johnstone of Liverpool University. He has, by personal observation and wide reading, made himself master of the subject and he has a clear, lucid style which makes it a pleasure to read anything that comes from his pen. It is a vast subject, for Oceanography really passes into marine biology on one side, and into physical oceanography on another. Geography and geophysics enter into it, and to understand modern theories of tides and hydrodynamics requires mathematical knowledge of no mean order.

The book begins with a chapter on the ocean world, which is illustrated with a series of interesting photographs of the globe taken from various standpoints. In the third chapter we come at close grips with marine investigation, and the various modern instruments which are used in investigating the bottom of the ocean, and the intermediate depths are clearly described and illustrated. There is a vivid account of the way the land deposits are carried out to sea, forming the continental shelf which gradually dips at the continental slope into the deep sea. Our knowledge of deep-sea deposits, which is largely due to Sir John Murray and his helpers on the "Challenger," forms the subject of another fascinating chapter, and there is a careful analysis of the various views which are held as to the origin of coral reefs. We quote what may perhaps be regarded as a summing-up of this problem:

> *Are Coral reefs formed on subsiding regions?* This is the main problem and it is one for geological investigation. Where such investigation has been most successful it seems to be established that reef areas are also, in general, areas of subsidence of the ocean floor. In the West Indies, for instance, there are satisfactory evidences of depression or downward tilting of a large area of sea bottom in the seaward direction; there are deeply indented bays and

valleys, steeply sloping sea bottoms, drowned escarpments and submerged peat deposits. Most important of all, there is geological evidence (from the West Indies and Southern United States) that fossil reefs occur, and *that these rest unconformably on eroded submarine platforms*. There is also evidence that this is the case with living reefs. Coral reefs appear, therefore, to become established on submerged rock platforms. This is the case with fringing and barrier reefs and also with atolls. There is no evidence that these grow up round subsiding cones, but rather that they are based on submarine flat summits.

Other subjects dealt with are the margins of the ocean, the chemistry of sea-water and its physical characteristics, the tides, oceanic circulation (which occupies a very large section of the volume) and the secular changes in the sea. Enough has been said to show that this book is one that no student of Oceanography can afford to overlook. Even the most difficult problems are lucidly explained. The book is well printed and is provided with a good index.

A School Chemistry. By O. J. FLECKER, B.Sc. (Oxford University Press. 3*s*. 6*d*. net).

Teachers who are looking for a compact practical course of Inorganic Chemistry, and general readers who wish to acquaint themselves with a satisfactory outline of the subject without being bewildered by a host of unnecessary details, can be cordially recommended to acquaint themselves with this book. An outstanding feature is the fact that stress is laid from the outset on the principles of Physical Chemistry, which are briefly and clearly described at appropriate points in the development of the experimental course.

The applications of Chemistry have also been kept in mind by the writer, who has been careful not to lose his sense of proportion, but to indicate in brief but judicious notes, the relation of the experimental results to various aspects of chemical industry. In view of the fact, however, that the making of both oxygen and sulphuric acid (as suggested in this book) employ catalytic methods, it would undoubtedly improve a future edition if a simple but adequate account could be included of the theory of catalysis.

Relativity for Physics Students. By G. B. JEFFERY, M.A., D.Sc. (Methuen. 6*s*. net).

This is not only one of the most interesting books on Relativity in the excellent series which Messrs. Methuen have published on this subject, but it is incidentally one of the clearest and most illuminating short accounts which we have yet seen of Einstein's work. This is partly due to the author's grasp of his subject, and his enthusiasm for it, as well as his extraordinary skill in exposition. But it is probably also in part accounted for by the fact that Professor Jeffrey has hit upon the right kind of audience to which he should explain what he regards as "the most outstanding physical theory of (our) generation."

Most previous attempts to explain Relativity have failed to enlighten the man of average education, because they have been written for totally unsuitable audiences. For instance, a number of books have tried to give an "A B C" of the subject, suitable for the man in the street. Many of these books have been interesting, and a few even amusing, but—they have failed to give us the slightest inkling that Relativity really matters either to ourselves or to Science. Their writers have assumed so little knowledge—either of science or mathematics—that it has been impossible for them to give any satisfactory idea either of Einstein's reasoning, or of the scientific setting of his doctrines. On the other hand, numerous books have been written for the expert mathematician. These assume far too much for most of us, and only convince us of the tremendous gulf that exists between Einstein's method of thinking and our own.

This book adopts a sensible midway position. To appreciate Relativity, we need some knowledge both of science and mathematics. Professor Jeffrey assumes just as much knowledge of both as is possessed by the average physics student undergoing a university course. This is sufficient for his purpose, and there must be a host of readers who can offer something approaching this background of knowledge.

The book consists of six lectures delivered to physics students at King's College, London, and one delivered as an Inaugural Lecture in Mathematics at the same college. The first two lectures are mainly scientific and historical, and show in a very understandable fashion the way in which Einstein's theory fills a real gap in physical science. We are given a brief but satisfactory outline of the development of modern mechanics, from the pioneer work of Tycho Brahe, collecting volumes of figures with the aid of no telescope and the most primitive instruments, to Kepler, Galileo, and finally Newton, who first realised the existence of the relativity problem.

From Newton on we are given a very clear insight into the need which was felt for some fixed standards or axes of reference, from which motion could be measured in an absolute, instead of a merely relative, way. Newton's absolute space adopted the fixed stars as being outside the solar system, and apparently unaffected by its motion, "although even Newton had his doubts as to the reasonableness of this supposition." When "subsequent discovery proved the wisdom of this reservation," we are shown how unsatisfactory the position of the whole science of mechanics proved to be.

Finally an investigation of the development of the sciences of optics, electricity and magnetism shows that these, too, found themselves with a "missing link" that even the ether failed to fill. Einstein's doctrine of relativity overcame the difficulty, and solved a problem which we are made to see was real and essential.

In the later lectures, a moderate use of mathematics is called for, although even here the writer takes great pains to give every assistance possible by means of verbal descriptions. As a result, he may fairly claim to have helped the really serious reader, who is prepared to face the necessary difficulties of the argument, "to smooth the way" to a full understanding of the theory "by a preliminary exploration of the ground."

Social Aspects of Psycho-Analysis. By ERNEST JONES, JAMES GLOVER, J. C. FLUGEL, M. D. EDER, BARBARA LOW, and ELLA SHARPE. Edited by ERNEST JONES, M.D. (Williams & Norgate. 7*s*. 6*d*. net).

A series of lectures delivered by members of the British Psycho-Analytical Society before the Sociological Society.

The first two lectures, by the editor and Dr. Glover, give a clear account of the general theories held to-day by Professor Freud and his followers; subsequent lectures, dealing with psycho-analysis in relation to the family, to education, and to the choice of a vocation, indicate the scope for a practical application of these theories and the possibility of finding an explanation of many sociological problems in the unconscious motives revealed in the individual by the technique of psycho-analysis.

Dr. Eder, in a lecture on psycho-analysis and politics, goes rather further and boldly reveals some surprising, and for the most part very uncommendable, unconscious motives for Conservatism, Capitalism, etc.

The book is valuable as an authoritative statement of the

psycho-analytical theories, and will be the more acceptable to the general reader for being entirely concerned with relatively normal psychology. Its weakness is a tendency to over-emphasize a little the indubitability of the theories propounded, and the occasional failure to make a clear distinction for the reader between generalisations from observed facts and ingenious speculation.

British (Terra Nova) Antarctic Expedition 1910-1913 : *Report on the Maps and Surveys.* F. DEBENHAM, O.B.E., B.A., B.Sc. (Price 10*s.*) ; *The Physiography of the Ross Archipelago.* F. DEBENHAM. (Price 5*s.*) ; *Physiography of the Beardmore Glacier Region.* C. S. WRIGHT, O.B.E., M.C., B.A. (Price 5*s.*) ; *Physiography : Robertson Bay and Terra Nova Bay Regions.* R. E. PRIESTLEY, M.C., M.A. (Price 7*s.* 6*d.*). (London : Harrison & Sons, Ltd., for the Committee of the Captain Scott Antarctic Fund, 1923).

The last expedition of Captain Scott has proved fortunate at least in one respect and that is the publication of its scientific results. More than one Antarctic expedition has been forced to curtail and even to suspend the publication of its researches owing to lack of funds. Thus the most useful even if least spectacular part of its labours is wasted. In the case of the *Terra Nova* expedition of 1910-1913 no such misfortune occurred. Very wisely a part of the memorial fund to Captain Scott and his four companions was set aside to assist publication. A better tribute to Scott's endeavours could not have been devised. These four reports are the latest addition to a long series of valuable monographs which is now nearing completion. Three of the reports deal with the physiography of as many different and widely separated areas. Mr. Wright produces a report on what is probably the most remarkable glacier valley in the world. His researches were necessarily incomplete as the work had to be done in passing with the southern sledge party and returning with a supporting party. On such marches delay and deviation from the course are impossible. Many of his conclusions are therefore tentative suggestions but are none the less of interest. It has been suggested that a glacier like the Beardmore which taps the continental ice through the bounding fault-range of the plateau is due to the backward extension of cwms. But Mr. Wright does not believe that such a result can be attributed to this action even if it were assisted by planes of weakness in the underlying rock or by preglacial drainage lines. He inclines rather to the belief that such a glacier starts from above by overflow from the ice of the plateau wherever a gap in the fringing mountains permits, the gaps of course being due to planes of weakness or preglacial drainage. Mr. Priestley in his studies of South Victoria Land also combats the great significance that has even assigned to cwm action in sculpturing Antarctic land masses. He enters at length into the evidence for and against the erosive action of Antarctic glaciers and disagrees with the view that glaciers are inefficient erosive agents even though he admits that the present slow rate of movement of Antarctic glaciers is inconsistent with vigorous work. In the past there can be no doubt that the glaciers in full flood of ice moved more quickly. The evidence on these important points is carefully weighed and deserves study by all geographers ; it is too lengthy to set forth in a review. Of Mr. Debenham's two reports, the first deals with the peculiar topography of the volcanic Ross Archipelago at the north-west corner of the Great Ice Barrier, the classic ground of several British expeditions. The second is the volume on maps and survey including a portfolio of fourteen maps. It represents a remarkable record of high-grade work. The cartographical work of the expedition was in the hands of Lieut. (now Captain) E. R. G. R. Evans, R.N., Lieut. H. de P. Rennick, R.N. and Lieut. H. L. Pennell, R.N. The last two had completed much of the preliminary drawing of charts before the war in which both lost their lives. To Mr. Debenham thus fell the work and he has admirably completed the task of which for several reasons the greater part remained to be done. For most parts covered by the expedition partial and often rough surveys were already in existence. These have been utilized and in many cases have been of much assistance. Unfortunately the details of the Norwegian work in King Edward Land are not yet available. They might have added to the empty map of that little-known region. The McMurdo Sound and Ross Island region is now the best-known part of Antarctica, and is well enough surveyed to allow of large-scale charts. Full details are given of the South Pole observations. Mr. Debenham, recalculating positions from Lieut. Bowers' observations, gives Scott's polar position no greater an error than $\pm 30''$. An account is given of the survey instruments used on the expedition and Mr. Debenham adds a valuable chapter on survey work of the future in the course of which he lays stress on the value of the plane table in polar work and makes a good case for its employment. He concludes with an important plan for the measurement of an arc of meridian in a high southern latitude. This would prove relatively easy on the coast of South Victoria Land where many suitable peaks and several offshore islands occur. A sketch map illustrates the possibilities of triangulation along this coast. It should be noted that all the reports are admirably illustrated and published at very moderate prices. R.N.R.B.

Farm Soil and its Improvement. By SIR JOHN RUSSELL, F.R.S. (Ernest Benn Ltd. 7*s.* 6*d.*).

The soil can be and has been made much more reproductive by the use of fertilizers specially adapted to its conditions. The food supply of England is a matter of first-rate importance, and agriculture is still our greatest industry. Sir John Russell is an authority whose name carries weight throughout the country, and unlike many specialists he is able to give in terse and lucid sentences the results of recent experiments. Readers of DISCOVERY are familiar with some of the results obtained at Rothamsted, and we believe that all who are directly interested in tillage problems will find in this book information that will be of the greatest practical value. The application of scientific methods to agriculture is a great necessity of the times and with co-operation on the part of farmers it can raise the industry from its present depressed condition.

CORRESPONDENCE.

To the Editor of DISCOVERY.

SIR,

You kindly allowed me to defer to the latest date, in the hope that more definite information might come to hand, the article on the supposed discovery of the lost Books of Livy. The consequence was, that one or two slips of mine and the printers remained in need of correction which I should be glad if you will allow me to supply, adding that the same exigency precluded certain changes which I desired in the editorial heading.

Manchester. Yours faithfully,

10*th October*, 1924. R. S. CONWAY.

CORRECTIONS.

p. 260, col. *b*, l. 3 *read* Torquatus.
l. 17 *read* in Scipio's career.
l. 22 *read* general.
p. 262, col. *b*, l. 2 *read* portray.

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